ENGINEERING:

An Illustrated Weekly Journal.

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Plans may be seen at the above address.

Sealed Tenders on the form supplied (which must not be detached from the Specification and Quantities) to be delivered to the TOWN CLERK, Guildhall, Northampton, not later than 12 o'clock noon on Tuesday, the 19th day of August, 1919.

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An official receipt must be obtained for any tender delivered by hand. Tenders sent by post must be registered.

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1 STEEL WORK FOR BRIDGES	10/-
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The Directors do not bind themselves to accept the lowest or any Tender.

R. H. WALPOLE,
Secretary.

Company's Offices,
45, Copthall Avenue, E.C.,
London, 6th August, 1919. X 677

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BY DIRECTION OF THE DISPOSAL BOARD.

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The Specifications and Drawings can be seen at but not obtained from, the office of Sir Alexander B. W. Kennedy, 17, Victoria Street, Westminster, London, S.W.

Tenders on the prescribed form, enclosed in sealed envelope and endorsed on the outside, "Electricity Supply, Tender for Specification No. 20 or 21," must be delivered at the office of the undersigned not later than Thursday, 11th September, at 10 a.m. The Council do not bind themselves to accept the lowest or any offer.

A. GRIERSON, S.S.C.,
City Chambers, Edinburgh. Town Clerk.
4th August, 1919. X 648

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Applications to be sent before September 1st, to THE ACTING WARDEN, Goldsmiths' College, New Cross, S.E. 14. X 647

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Appointments for the

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(4) LECTURER IN ECONOMICS AND COMMERCE.

Applicants should possess a University Degree in Commerce, and practical business experience is desirable. Salary £350 per annum, rising by annual increments of £25 per annum to £450.

(5) LECTURER IN FRENCH AND GERMAN CORRESPONDENCE.

Applicants should have had actual business experience as Foreign Correspondents, preferably with an engineering firm. Salary £300 per annum, rising by £25 per annum, to £350, further increments being considered subject to satisfactory service.

Applications, with not less than three recent testimonials, should be submitted before August 27th to the PRINCIPAL, from whom forms of application and any further particulars may be obtained.

W. A. BROCKINGTON, O.B.E., M.A.,
Director of Education.
X 637

LONDON COUNTY COUNCIL.

Applications are Invited for

the undermentioned POSITIONS in the Mechanical Engineering Departments of the respective Institutions :—

Hackney Institute—ONE WORKSHOP SUPERINTENDENT, THREE WORKSHOP INSTRUCTORS, ONE WORKSHOP ASSISTANT (Youth), ONE TEMPORARY STOREKEEPER (Female).

Paddington Technical Institute—ONE WORKSHOP SUPERINTENDENT, THREE WORKSHOP INSTRUCTORS, TWO WORKSHOP ASSISTANTS (Youths), ONE TEMPORARY STOREKEEPER (Male or Female).

School of Engineering and Navigation, Poplar—TWO WORKSHOP INSTRUCTORS.

Salaries and wages are—

Workshop Superintendent—£325 rising by £10 to £440 a year (inclusive).

Workshop Instructor—£275 rising by £10 to £340 a year (inclusive).

Candidates must have had at least five years' industrial experience after 21 years of age.

Workshop Assistant (Youth)—18s. rising by 1s. to 30s. a week (a minimum wage of 26s. on reaching 21 years of age) together with temporary bonus of 17s. to 23s. a week and for the current year a 50% addition to the weekly wages.

Temporary Storekeeper—(Male) 65s. a week, (Female) 40s. rising by 1s. to 45s. a week (inclusive).

It is essential that applicants for the teaching positions should have had recent workshop experience in modern engineering practice, and be competent to give instruction in the use of machine tools.

Preference will be given to persons who have served or attempted to serve with the Forces of the Crown. Application forms may be obtained from the EDUCATION OFFICER (T.I.), Education Offices, Victoria Embankment, W.C. (stamped addressed foolscap envelope necessary). Form must be returned by Eleven a.m. on 19th September, 1919. Canvassing disqualifies.

JAMES BIRD,
Clerk of the London County Council.
X 668

THE USE OF RAW TARS AS FUELS FOR DIESEL ENGINES.

By Harold Moore, M.Sc.Tech.

The development and commercial success of the various types of internal-combustion engines running on liquid fuels have been almost entirely governed by the economics (*i.e.*, price, available quantity, import tariffs, &c.) of the fuels which they were designed to employ. When the constant-pressure cycle engine or Diesel engine was first sold as an oil engine the available margin of choice of fuels was very narrow. Kerosene, the fraction obtained between 150 deg. and 300 deg. C. in the distillation of petroleum, was suitable, and the heavier distillates such as solar and gas oils were also found to be satisfactory fuels. The range of fuels was then increased by including the better grade "crude oils" which usually consist of depetrolised crude petroleum. As a result of the economic advantage obtained by burning the poorer grade petroleum residua, improvements in the design of engine were introduced, and consequently the major portion of the heavy petroleum residua became available for service in Diesel engines. Certain of the highly asphaltic petroleum residua are, however, still outside the range of fuels suitable for general use.

The difficulties of transport and the large demands of the Admiralty for heavy oil during the early part of the war resulted in the adoption of the heavier tar distillates as substitutes for petroleum, though previous to the war there had not been sufficient advantage in price to warrant the change from petroleum oils to tar distillates when the lower heat value of the latter was taken into account. Tar distillates and even raw tars had been successfully employed on Diesel engines on the Continent at an earlier date as a result of the acute petroleum shortage caused by import tariffs, and a considerable portion of the tar oils employed in this country during the war were utilised with the assistance of the pilot ignition gear, a device which had been invented and developed on the Continent before the war.

Numerous papers have been published in which information concerning the use of tar distillates on Diesel engines has been given, and the writer has dealt with this subject at considerable length elsewhere.*

We may summarise our knowledge of the chemical and physical properties of tar oils, and our practical experience of their behaviour in Diesel engines by the following remarks:—

1. The temperatures of spontaneous ignition of tar oils are much higher than those of petroleum oils. This results in ignition troubles when employing engines of standard design.

2. Tar oils are liable to form precipitates under the action of heat and compressed air. This may result in obstruction of the atomising devices.

3. Tar oils are richer in carbon and lower in hydrogen content than petroleum oils, and they are therefore more liable to precipitate carbon on the walls of the combustion space if not burnt under entirely favourable conditions. The main effect of this property of these oils is an increased wear on the exhaust valve face and seat.

The ignition difficulties with tar oils have been overcome by the employment of a variety of devices of which the pilot ignition system, which provides for the introduction of a small charge of a petroleum or shale oil into the cylinder prior to the main fuel charge, has been the most generally utilised. Obstruction of the normal atomising devices has become less frequent since greater attention has been given to the analyses of the tar oils, and this trouble has been overcome in several instances by the use of atomisers of special design. The increased wear of exhaust valves when employing tar oils is not very great, and only necessitates more frequent attention to this part.

Since the end of last year the price of the heavy tar distillates has rapidly increased, while the prices of the competing imported petroleum fuel oils have fallen. The economic advantage to be gained by burning tar oils has therefore largely disappeared.

The prices of raw tars have during the last ten years been somewhat less than half the price of the heavy tar distillates, while their average heat value is only about 6 per cent. less than that of the tar oils, or approximately 15 per cent. less than that of the average petroleum oil. Also the tar oil supplies of the country are limited, the yield of heavy tar distillates from an average tar is approximately 33 per cent. Thus the supply of tar is three times as great as the quantity of tar oils prepared in the country. A large portion of the raw tar is quite unsuitable for direct burning in internal-combustion engines. Such tar is, however, valuable to the distiller and capable of yielding the creosote which is required for export to the American timber creosoting industry. As the raw tars present a favourable source of fuel for Diesel engines when viewed on general economic grounds, *i.e.*, as regards price, quantity available, facilities for distribution &c., a few notes on their properties as fuels may be of use to both manufacturers and users of Diesel engines.

Raw tars, when used as fuels for internal-combustion engines possess to a greater or less extent all the defects of tar oils, and in addition certain defects peculiar to themselves. There is also much wider variation in the physical and chemical properties of the different tars than the usual limits of variation observed in the analysis of tar oils. This latter fact necessitates the continual and most detailed analysis of raw tars, not only tar from each new source requiring analysis, but each new delivery.

Raw tars generally possess spontaneous ignition temperatures about the same or slightly lower than those of tar oils (about 200 deg. C. higher than the average petroleum oils; *i.e.*, about 460 deg. C. for tar oils and 260 deg. C. for petroleum oils), and they present the same ignition problems. This difficulty has in many cases been overcome by adopting the pilot ignition system and using a petroleum oil for ignition purposes. Some large Diesel-engine installations on the Continent are said to have worked satisfactorily with raw tars, using a small pilot charge of the tar itself injected into the cylinder considerably in advance of the normal timing. The use of petroleum for starting purposes, which is a common practice when burning tar oils, presents greater difficulties when employing raw tars as main fuel, as deposits are formed by the addition of petroleum to raw tar, and these are greater in quantity and more viscous than the deposits which are formed by tar oil-petroleum mixtures. These deposits interfere with the working of the fuel-pump valves. Specially-chosen tars of low free carbon content do not so readily cause obstruction of the atomising devices as do certain tar oils. Whereas tar oils usually either keep clean or else readily cause obstruction, the tars more usually cause slight obstruction. It is, however, preferable to employ special atomising devices for use with raw tars. The deposits formed in atomisers when running on raw tar are probably caused by the accumulation of free carbon.

A trouble frequently encountered when burning raw tars or other pitch or asphalt containing fuels is the formation of gummy deposits on the fuel valve stem, which is due to the partial distillation of fuel which has crept up the fuel valve. This may readily interfere with the working of the valve. It is a trouble seldom encountered when burning tar oils. It can be surmounted by the employment of devices for preventing the creeping of fuel up the valve stem.

The third trouble mentioned as being experienced in burning tar oil is the extra wear on the exhaust valve caused by precipitation of carbon when the conditions of combustion are not satisfactory. The same trouble is occasionally encountered when burning petroleum under unfavourable conditions.

The wear on the exhaust valve is much more pronounced when burning raw tar than with petroleum oils or tar oils. Whereas with the latter fuels it is only necessary to prevent the precipitation of carbon, with raw tars precipitated carbon is already present in the form of the so-called "free carbon," and for satisfactory running it is essential to burn this free carbon during the cycle before the opening of the exhaust valve. On account of the particles of free carbon burning less rapidly than the remainder of the fuel there is considerable danger, when burning raw tars, of the exhaust valve opening before the combustion of the free carbon particles is complete. If incomplete combustion takes place glowing particles are trapped between the valve face and the seat, which results in pitting of the valve face, and this, if allowed to become pronounced will cause loss of compression and subsequent starting troubles. Seizure of the exhaust valve stem is also likely to occur. Increase of compression causes higher temperature in the combustion space and therefore accelerates combustion. High engine speeds afford less time for complete combustion, and therefore cleaner running is experienced at slower speeds, a fact which the Continental makers appear to have realised, as Continental engines running on raw tars generally work at low speeds.

The majority of petroleum and tar oils contain less than 0·02 per cent. of ash, and it is rarely, therefore, that ash troubles are noticeable on engines employing these fuels. As tars contain much greater quantities of ash, and in many cases cannot be employed on account of ash trouble, a much greater wear on the piston rings and liner may be expected when engines are running on tars than when employing tar oils.

As raw tars are frequently high in viscosity there is often difficulty in freeing them from water, which does not readily separate out. The presence of water causes misfiring and irregular running.

The removal of water from raw tars presents considerable difficulty, the only method which finds general use being by "settling" or allowing the tar to stand for two or more days in large storage tanks, which are maintained at a temperature of about 100 deg. F.

The removal of water from carburetted water gas tar has been effected by the use of centrifugal machines. This tar is particularly difficult to separate from the water as the specific gravities of the tar and the water are about the same values, the tar averaging about 1·05 specific gravity, and the water, owing to salts in solution, being about the same. In order to facilitate separation, brine may be added to the wet tar, thus increasing the density of the aqueous portion, while warming the mixture further increases the difference in densities as the coefficient of expansion of the tar is greater than that of water. These measures may be employed when adopting either the centrifugal or settling methods of separation.

It has also been claimed that centrifugal treatment removes some of the free carbon and some of the ash content of tars. Filter press treatment has not been found to satisfactorily remove either free carbon or ash. It has recently been claimed that the percolation of the tar through gravel filters is a method of removing some of the free carbon from tars. The removal of free carbon from tar has been successfully carried out in the United States by filtering under high pressure through wooden plugs, the liquid portion of the tar passing longitudinally down the grain of the wood.

On account of the high viscosity of tars it is generally advisable and sometimes absolutely necessary to employ a preheater, so situated that it will ensure the oil being warm when passing through the service pipes. Such preheaters may derive their heat from the exhaust circulating water supply, high-pressure delivery pipe from compressor, or from a separate source, *e.g.*, from an electric resistance. The latter type possesses the advantage of being independent of the engine and consequently it being possible to heat the oil before the engine is started up.

The Properties of Tars.—Both the yield and the chemical constitution and physical properties of tars depend mainly upon the following factors:—

1. The nature of the coal from which the tar originates.

2. The rate of heating the coal during carbonisation.

3. The maximum temperature to which carbonisation is carried.

4. The speed and method of removal of the volatile products from the retort during carbonisation.

Coals rich in volatile matter yield comparatively

*Liquid Fuels for Internal Combustion Engines; Crosby, Lockwood and Son.

large quantities of tar. Rapid heating of the charge during carbonisation tends to reduce the quantity of tar and to form tars rich in free carbon and aromatic compounds. Gradual raising of the temperature of the retort or oven results in greater yields of tar, with lower free carbon content and a higher proportion of aliphatic hydrocarbons.

A high maximum temperature ensures complete removal of volatile matter from the coke and raises the proportion of free carbon and aromatic compounds in the tar. Rapid removal of the volatile matter from the retort ensures high yields of tars comparatively free from free carbon and rich in aliphatic bodies.

From the Diesel engine user's point of view we require large yields of tar rich in aliphatic bodies and low in free carbon content.

Gas works in this country employ plant of three types; horizontal retorts, inclined retorts and vertical retorts. Horizontal retorts are generally present in the older installations; modern plan consists more frequently of vertical retorts.

The horizontal retorts do not allow sufficiently rapid removal of volatile products, and are also so constructed that the volatile products pass along the retort walls and become decomposed, which results in low yields of highly viscous black tar rich in aromatic bodies and free carbon.

Vertical retorts may be worked either intermittently or continuously, but in both types the conditions are such that high yields of mobile dark brown tars result. These tars are comparatively low in free carbon content and rich in aliphatic bodies, and are therefore particularly suited for use on Diesel engines. The tar from Dessau intermittent vertical retorts has been used in quantity on Continental Diesel engines.

Inclined retorts give tars more closely akin to the tars from horizontal retorts, though usually slightly lower in free carbon content.

Coke ovens vary considerably in construction, and the tars obtained from them are very irregular in their properties. Of the coke oven tars examined by the writer those originating from Simon Carvé ovens were found most suitable for use as fuel for Diesel engines.

In addition to the gas works and coke-oven tars, certain tars from low-temperature carbonising plants have been examined with a view to their use on Diesel engines. These tars have been obtained by the carbonisation of coal at low temperatures in plants provided with special arrangements to ensure the rapid removal of the volatile products. The free carbon content of such tars is very small, and the hydrocarbons of which the bulk of the tar consists are mainly aliphatic.

The removal of water from the tars presents a serious difficulty, as the water is emulsified and cannot be separated by the usual method of warming the mixture and allowing it to settle.

The above-mentioned tars are all derived from coal, but tars from other sources, particularly lignite tars, must not be overlooked.

Lignite or brown coal is found in large quantities in Saxony, where a highly-developed lignite industry exists. Though it is not worked in this country, lignite fields are widely spread over the British Empire. By destructive distillation lignite yields a brown tar of buttery consistency, which consists mainly of aliphatic hydrocarbons. This tar is practically devoid of free carbon, but rich in solid hydrocarbons of the unsaturated aliphatic series (akin to paraffin wax).

This tar, according to Continental authorities, can be satisfactorily burnt in Diesel engines without ignition gears or any other special modifications. It behaves in the engine similarly to petroleum and shale oils.

By the carbonisation of peat a mobile tar of the aliphatic type is obtained. This might prove a suitable fuel for heavy oil engines, but at present the carbonisation of peat is not being carried out on a sufficiently large scale to allow of the use of the liquid products for fuel purposes.

It is common practice in normal times for gas works in this country to manufacture a portion of the lighting gas by "cracking" a heavy petroleum distillate and mixing the resulting oil gas with water gas. During this process oil gas tar, also known as "carburetted water gas tar," is produced.

This tar is not a coal tar, but originates from petroleum. It is frequently mixed with water in the form of emulsion, and the greatest difficulty is then experienced in effecting its separation. Though a product of petroleum, oil gas tar consists mainly of aromatic hydrocarbons, the larger portion of the original hydrocarbons having undergone complete transformation during the cracking process.

When free from water and ash, oil gas tar behaves in a Diesel engine in a very similar manner to tar oil, but does not cause pulveriser choking. The ash content of oil gas tar is very variable, and when attempting to run on this fuel analyses of each batch for water and ash content must be made before accepting delivery.

—	Specific Gravity.	Ash.	Coke.	Free Carbon.	Net Heat Value in Calories. (Dry Tar.)	British Thermal Units.
		per cent.	per cent.	per cent.		
Horizontal retort tar ..	1·15 to 1·23	0·0 to 0·1	20·0 to 35·0	15·0 to 30·0	8,700 to 8,850	15,660 to 15,930
Inclined retort tar ..	1·12 to 1·18	0·0 to 0·1	15·0 to 25·0	10·0 to 20·0	8,750 to 8,900	15,750 to 16,020
Vertical retort tar ..	1·05 to 1·12	0·0 to 0·1	5·0 to 10·0	1·0 to 7·0	8,800 to 9,000	15,840 to 16,200
Coke oven tar	1·08 to 1·20	0·0 to 0·3	5·0 to 25·0	1·0 to 25·0	8,600 to 9,250	15,480 to 16,650
Low temperature carbonisation tar	1·05	0·1	8·0	2·0	8,776	15,797
Oil gas tar	1·03 to 1·12	0·0 to 0·4	3·0 to 10·0	0·5 to 5·0	9,100 to 9,500	16,380 to 17,100
Lignite tar	0·96 to 1·09	0·07 to 0·4	0·5 to 7·0	0·0 to 5·0	9,100 to 9,800	16,380 to 17,640

Of the tars given in the above list those from horizontal and inclined retorts have hitherto proved quite unsuitable for use in internal-combustion engines on account of their high free carbon contents.

Intermittent vertical retorts (of the Dessau type) are largely used in Germany, and yield tar of slightly lower average free carbon content than that from continuous vertical retorts, of which a large number are installed in this country.

Some of the tar obtained from coke ovens might be used for engines, but probably the quantity would not be very great. Oil gas tar is not being produced in great quantity in this country at the time of writing on account of the high price of petroleum oil, and even in normal times the quantity available is comparatively very small. Neither low temperature carbonisation, peat distillation, nor lignite carbonising plants are working in quantity in this country.

Of the tars mentioned, only vertical-retort tar and some coke-oven tar are available for use in quantity, and it is on these, particularly on vertical-retort tar, that we shall have to concentrate our attention in the near future. Tar from vertical retorts and coke ovens was available before the war at a price of about 30s. per ton, while tar oils were commanding a price of about 60s. per ton. The price of the distillate is usually slightly over double the price of the raw product. Though the heat values of suitable tars are approximately the same as those of tar oils they show slightly higher consumptions per brake horse-power-hour as the thermal efficiencies are reduced by the higher viscosity of the raw product.

With engines of over 100 brake horse-power the full-load consumption for raw tars is approximately 0·55 lb. per brake horse-power-hour. Certain allowances would have to be made when engines are to run on raw tars. It is to be noted that:—

1. The maximum mean effective pressure on the engine will be slightly lower than the normal.

2. The speed of engines running over 200 r.p.m. would probably have to be reduced, with corresponding reduction in load.

3. The attendants would have to be more skilled than is normally necessary.

4. The wear and tear on working parts of engine would be slightly in excess of the normal.

In spite of these disadvantages there should be a marked economy due to the great difference in fuel costs.

A specification to ensure a suitable quality of tar for use in Diesel engines would have to be drawn up on the following lines:—

1. The tar must possess a specific gravity below 1·12.

2. The tar must not contain more than 0·08 per cent. of ash.

3. The tar must not contain more than 2 per cent. of water.

4. The tar must yield at least 9,100 calories gross heat value (16,380 British thermal units).

5. The tar must not contain more than 6 per cent. of free carbon (insoluble in mixture of toluol and glacial acetic acid).

6. The tar must not yield more than 10 per cent. coke value.

Clauses 1 and 6 would ensure the tars not containing excessive amounts of pitchy substances. The water, ash and free carbon limits are fairly stringent, and would prevent certain tars from satisfying the specification; they are, however, necessary.

HELL GATE BRIDGE, NEW YORK.

By Frank W. Skinner, M.Am.Soc.C.E.

The four-track Hell Gate arch across the East River, New York, has much the greatest capacity and longest span of any similar structure in the world, and with its approaches forms a bridge and viaduct about 17,958 ft. long with many unusual structural features. It illustrates advanced practice in American bridge building, and is the most important and conspicuous portion of the New York connecting railroad with a present length of about 3·73 miles in the boroughs of the Bronx, Queens and Brooklyn in Greater New York. These features may be clearly seen in the plans, Figs. 1 and 2, on the opposite page. The construction of this railroad was commenced in July, 1912, and, it is estimated, will cost about 27,000,000 dols. when the road is completed by an extension of about 5·23 miles chiefly of ordinary double track construction without difficult structures.

The connecting railroad is an important link in the Pennsylvania Railroad system, and is designed to provide continuous rail communication for the enormous freight and passenger traffic, through New York City, between Canada, the New England States, and the Southern and Western States. It connects with the New York City terminal of the New York Central Railroad, the New York, New Haven and Hartford Railroad, and the Pennsylvania Railroad system on Manhattan and Long Island, and has an additional car float ferry service to the Greenville terminal yard of the Pennsylvania Railroad. It thus forms a belt line with these roads, including most of the vast commercial interests, ocean, and land terminals of the great New York foreign and domestic routes. It greatly relieves traffic congestion and the obstruction caused by car floats in upper New York Harbour and correspondingly expedites the movement of freight and the schedules of passenger trains. Freight traffic will predominate and passenger traffic will at present be limited to about 40 trains in each direction daily. Trains will eventually be operated by electric locomotives exclusively.

The franchise for the construction of the connecting railroad was granted in February, 1907, and notwithstanding injunctions and unforeseen difficulties that delayed the completion of the Hell Gate bridge for more than a year, traffic was established in March, 1917.

The East River Bridge division, 3·38 miles long, commences at the northern terminal and includes most of the structural work on the line, the bridges across the channels of the East and Bronx Rivers, and the long and lofty viaducts and embankments in their approaches and connecting them.

The principal officials of the New York Connecting Railroad are: Samuel Rea, President; the Pennsylvania Railroad Company, Howard Eliott President; the New York, New Haven and Hart-

ford Railroad Company and, for the East River Bridge Division, Gustav Lindenthal, Chief Engineer and Designer of Hell Gate Bridge and approaches, Henry Hornbostel, consulting architect, O. H. Ammann, assistant chief engineer, and H. W. Hudson, construction engineer.

The principal contractors were: American Bridge Company, for fabrication and erection of Hell Gate Bridge and 5,520 ft. of plate girder viaducts; Fraser, Brace and Co., for 11,800 lineal feet of concrete floor and conduit construction; T. A. Gillespie Co., for the concrete retaining walls and arches from Lawrence to Stemler Streets in Long Island City; Holbrook, Cabot and Rollins Corporation, for the earthfill between retaining walls; McClintic-Marshall Construction Company, for fabrication and erection of Little Hell Gate and Bronx Kill Bridges and 6,540 ft. of truss and plate girder viaducts; Arthur McMullen, for masonry and foundations of the Bronx Viaduct north of Bronx Kill; Patrick Ryan Construction Corporation, for the bridge and viaduct piers between Bronx Kill and Lawrence Street, Long Island, and the bases of the Hell Gate Bridge towers; and the Snare and Triest Co. for the Hell Gate Bridge towers above bases, for 2,750 lineal feet of concrete and timber floor construction, and for a number of the Long Island and Ward's Island viaduct piers. The pneumatic caisson foundations of the Ward's Island towers were built by the railroad company under direction of the Chief Engineer and P. G. Brown as Managing Engineer.

The data from which this paper has been prepared include notes and records made by the writer in personal investigation of methods and operations of design, fabrication and erection, information, drawings and photographs received from the American Bridge Company, the McClintic-Marshall Construction Company, and some of the other contractors above mentioned, largely from the chief engineer, Gustav Lindenthal, and especially from the assistant chief engineer, O. H. Ammann, and from his paper presented to the American Society of Civil Engineers from which some diagrams are here reproduced.

Fig. 1.

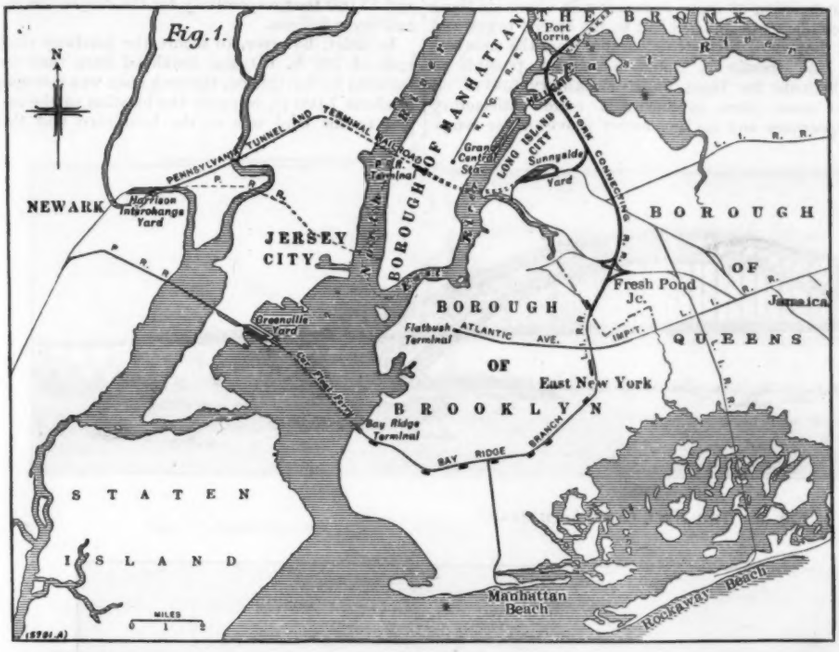
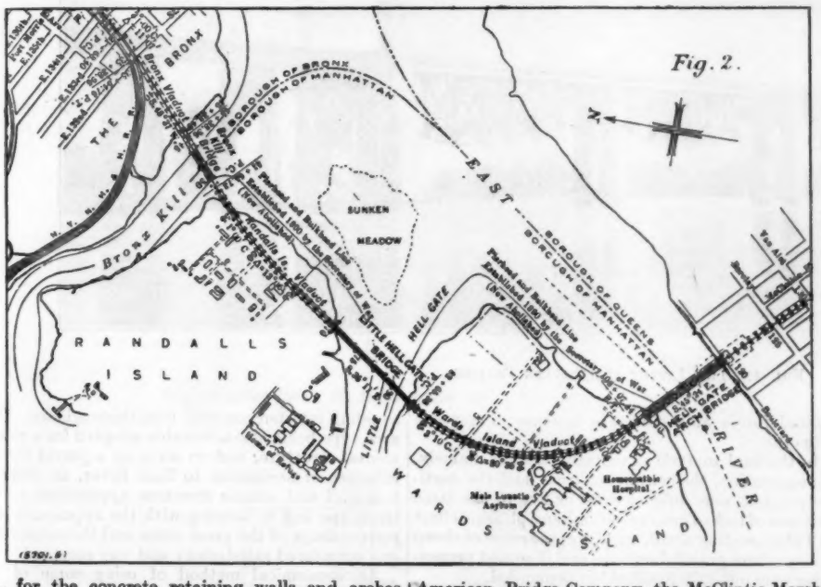


Fig. 2.



EAST RIVER BRIDGE SECTION.

The East River Bridge section, comprising about 3½ miles of the northern end of the connecting railroad is a four-track line with grades from 20 ft. to 130 ft. above the original surface of the ground and costing about 20,000,000 dols. Almost the entire length of this division, except the river crossings, is made up of steel plate girder and masonry and earthfill viaducts containing altogether about 90,000 tons of structural steel and 450,000 cubic yards of concrete reinforced with 5,000 tons of steel.

Its main structures are the 1,017-ft. span of the Hell Gate arch bridge (Fig. 3, on page 170) crossing the East River from Ward's Island to Long Island at a maximum height of 310 ft. above water level with foundations carried 110 ft. below water level; the little Hell Gate Bridge (Fig. 4) between Randall's Island and Ward's Island with four 292½-ft. spans, and the Bronx Kill Bridge from Randall's Island to the mainland, which is a double leaf 175-ft. span bascule type bridge installed at first as a fixed span with provisions for future installations of lifting machinery; and the viaducts, which consist of 11,000 ft. of plate girder spans with concrete arch piers, 1,200 ft. of deck truss spans over street, and 3,200 ft. of earthfill embankment between high concrete retaining walls pierced at street intersections with traffic openings spanned with concrete arches carrying the tracks.

Work on the viaduct was commenced simultaneously at both ends of the section in July, 1912, the foundations for the great arch span were begun in September, 1912, the erection of the steel arch was commenced in October, 1914, and the division was opened to passenger traffic in March, 1917.

HELL GATE ARCH SPAN.

The great arch span crosses the East River just below Hell Gate where there is a wide channel navigated by many small and large vessels. The channel forms a thoroughfare between Long Island Sound and New York Harbour for the important New England shipping trade that reaches the wharves and terminals in Brooklyn and on Manhattan Island, and has access through the great East River to New York Bays and the Atlantic Ocean.

The channel is both a river and an estuary subject to 6-ft. tides and 7 mile currents and obstructed nearby with reefs, sunken rocks and shallows and by a crooked channel where many accidents have occurred. It was therefore necessary not only to avoid temporary obstruction of the channel but to cross it at a great height sufficient for the clearance of the tall masts of large ships.

The structure became of great importance not only on account of the magnitude of both the marine and land traffic involved, the valuable character of the site, the amount of railroad traffic it was to carry, and also on account of its great prominence in the landscape where its height and dimensions make it conspicuous to a large portion of the boroughs of Manhattan, Bronx, Brooklyn, and Queens that with the smaller borough of Richmond form Greater New York, the home of nearly 6,000,000 inhabitants and the greatest financial, commercial, and maritime centre in America.

The importance of a railroad bridge at this point has long been recognised and active measures for its construction were taken in 1892 when a charter was secured and a double-track cantilever span 840 ft. long was designed by the late A. P. Boller (see Fig. 5, page 171). This bridge was supplementary to a 3,100-ft. suspension span designed by Gustav Lindenthal for the North River crossing, also for the Pennsylvania and Long Island Railroad system, the two bridges together affording direct connection from the main trunk lines in New Jersey, across Manhattan Island, and its river to Long Island, a combination that later gave way to the present connecting railroad system plus Pennsylvania Railroad tunnels under the North and East Rivers.

After the Long Island Railroad came under the control of the Pennsylvania Railroad in 1900, Mr. Lindenthal was appointed consulting engineer and architect to develop new designs for the East River Bridge and approaches to connect the New England railroads with the Pennsylvania Railroad by means of a New York connecting railway, and the East and North River Tunnels and the ferry from Long Island to New Jersey for handling freight. Comparative designs and estimates were made of the different types of long span bridges available for the Hell Gate crossing, and careful consideration was given to cantilever, suspension and continuous truss

spans of a uniform length of 850 ft. corresponding with the minimum width of the channel between the United States bulkhead lines. The total lengths of the structures varied from 1,450 ft. to 1,550 ft., but all were made for a loading equivalent to Cooper's E-50, which was then standard for the Pennsylvania Railroad Company. The spans were designed both for two-tracks and for four-tracks, the former to be made of ordinary carbon steel throughout and the latter to have nickel steel trusses. The estimated weight of the double-track spans was from 7,000 to 8,500 tons and for the four-track spans from 11,200 tons to 14,200 tons.

The suspension bridge (Fig. 6) was designed with chain eye bars forming the top chords of stiffening trusses of the three-hinge inverted arch type, the centre hinge being provided to make the stresses statically determinate and affected as little as possibly by foundation settlements. Both the weight and cost of this suspension span were estimated to be less than those of either of the other types. Its graceful appearance was very attractive and as a system of erection without falsework was proposed, the adoption of the design was recommended, and it would probably have been built but that before operations were commenced additional considerations developed that finally led to the arch span.

The next lightest and cheapest of the preliminary designs was that for the continuous truss structure having maximum rigidity and being susceptible of erection by the cantilever process that was realised to be the most advantageous for this locality. The outlines required and the general appearance of the continuous truss design for the greatest economy were much less attractive than those of other types and there was danger of indeterminate stresses in the event of irregular settlement. At the time its design was considered it was assumed that the main piers would rest on solid rock which, if true would eliminate indeterminate stresses in the trusses. A unusual feature of this design was the construction of the steel towers on the main piers above which the centre and end spans were continuous, these towers being hinged at top and bottom so as to be able to act as rocker bents and provide for considerable longitudinal displacement of the spans due to temperature changes (Fig. 7).

Mr. Lindenthal's cantilever design closely resembled Mr. Boller's previous design for an 840-ft. span except in the slight change of dimensions and in the substitution of slender hinged towers, similar to those of the continuous truss span design, instead of the wide lattice tower in the former design. The construction of these towers would eliminate those secondary stresses incident to the braced tower and as they were distinctly separated from the members of the trusses it would have been possible to substitute for them massive masonry towers on the same piers, producing a more satisfactory appearance and making better provision for longitudinal forces at a moderate increase of expense (Fig. 8).

In the final analysis all tentative designs, namely, the suspension, the continuous truss, and the cantilever spans, were subject more or less to the same criticism of lack of graceful outline and pleasing effect and of presenting a stiff, angular appearance of cheap utility where graceful outlines and dignified proportions were not only justified but demanded.

Development of the Arch Type Design.

After a study and comparison of the three ultimately rejected designs already considered, material changes in the requirements of the railroad and the results of a more complete subterranean exploration that indicated that solid foundations could be secured at a reasonable depth, led to the development of the final design on which the bridge was eventually constructed.

In 1905 the alignment of the railroad at one end of the bridge was shifted transversely, necessitating a curved and graded approach which would have required to be very sharp to provide for the comparatively long shore spans necessary in either the cantilever or suspension bridge designs. It was also evident that at the opposite end of the same span the location of the pier in the proper position at the bulkhead line would have involved a considerable expense in shifting the roadway of a handsome boulevard already existing at that point. On the other hand comparative estimates showed that at this place an arch span of equal length and capacity could be more economically constructed than either of the other types, requiring only about 13,000 tons of steel as compared with 14,000 tons and 17,000 tons respectively for the suspension and cantilever designs.

In order, however, to secure the headway clearance of 135 ft. between bulkhead lines that was required for navigation, the arch span was increased to about 1,000 ft. bringing the location of the east pier to the land side of the boulevard and thus avoiding interference with that thoroughfare. The arch type being also admirably adopted for a monumental structure, and to serve as a portal for the entrance of navigation to East River, as well as a beautiful and artistic structure appropriate to the landscape and in keeping with the appearance and surroundings of the great cities and the noble river, was considered satisfactory and was accepted.

An economical method of using some of the secondary members both for temporary service in the cantilever erection and for permanent service in the finished structure enabled the erection to be effected with marked economy, so that the bridge, although beautified by the additional expense of ornamental work on its massive towers that was not strictly required for the strength and safety of the structure, was still built at a cost about the same as that of the cantilever or suspension span under the same condition. Besides its beautiful appearance it has the advantage of greater rigidity under vertical loads than would have been developed in the other types, being subject to maximum deflections considerably less than those of the equivalent cantilever spans and no greater than those of a

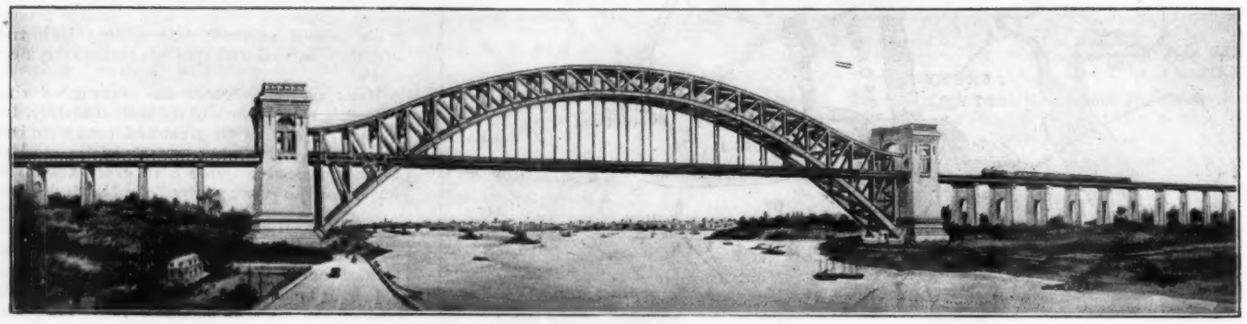


Fig. 3. The Hell Gate Arch Span.

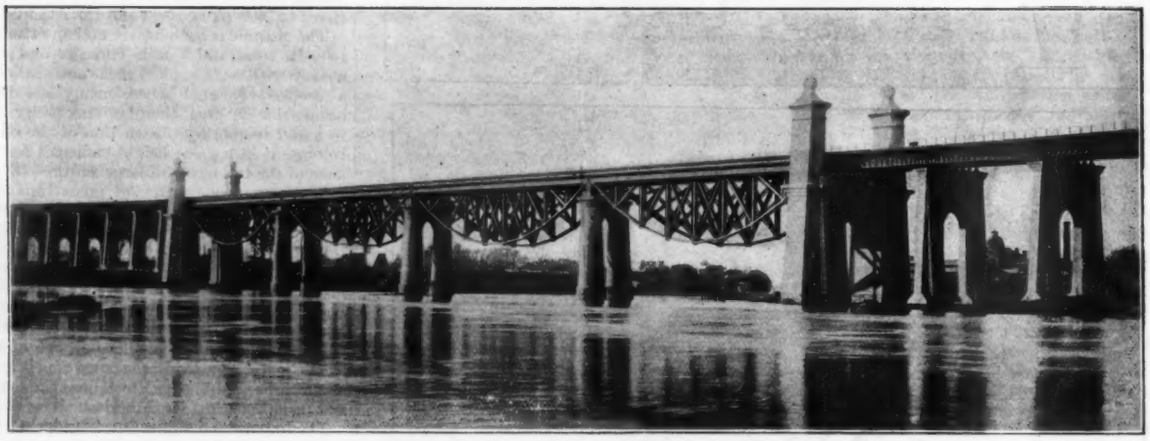


Fig. 4. The Little Hell Gate Bridge.

simple span. The secondary stresses are also smaller than those in most cantilever structures, and the expensive foundation work due to the unfavourable conditions developed at the west end of the bridge was offset by the saving in the cost of steel work.

In making the final selection of design two radically different types of trusses were considered.

Eventually the specifications were modified to provide for an increased live load corresponding to the very heavy E-60 requirements that had recently been adopted by some of the roads that were to use the bridge. Cantilever roadway platforms proportioned for trolley service were also added outside the trusses so that the final requirements increased the actual weight of the steel work to 18,900 tons.

Width 93 ft. between centres of railings; 60 ft. between centres of trusses. Figs. 11 to 15, page 172 give an idea of the general design of the bridge.

SUPERSTRUCTURE FEATURES.

The points of intersection of the bottom chords with the main arch ribs were determined by the clear height of 135 ft. required for a 700 ft. navigable

Fig. 5. CANTILEVER DESIGN (1900).

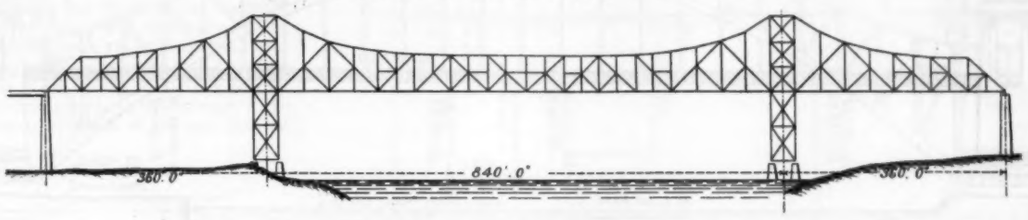


Fig. 6. SUSPENSION BRIDGE DESIGN (1904).

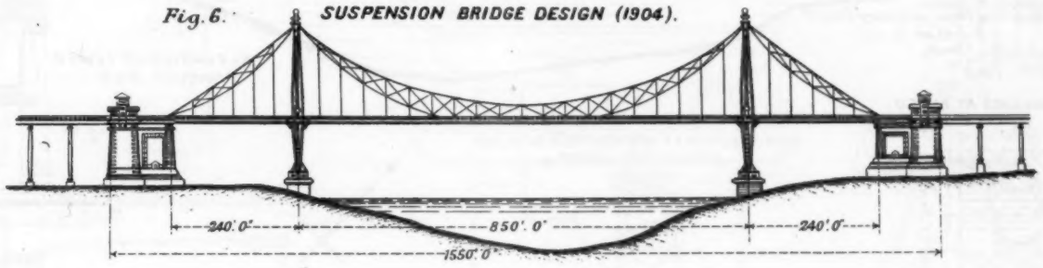


Fig. 7. CONTINUOUS TRUSS DESIGN (1904).

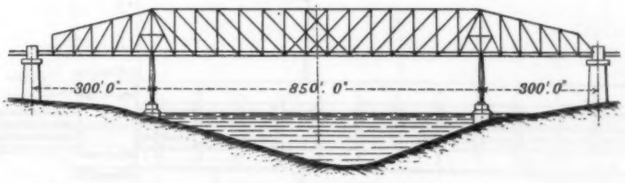


Fig. 8. CANTILEVER DESIGN (1904).

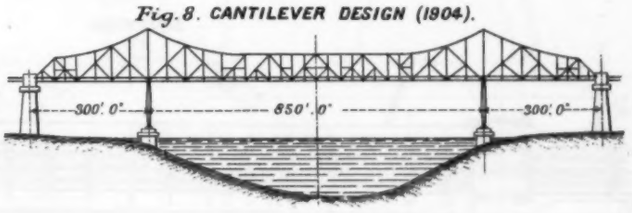


Fig. 9. CRESCENT ARCH DESIGN (1905).

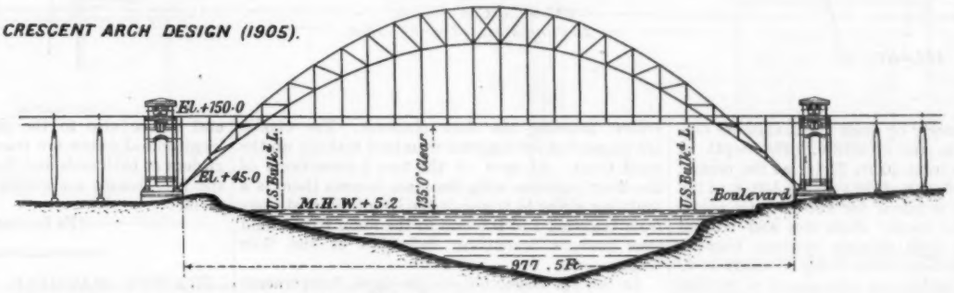
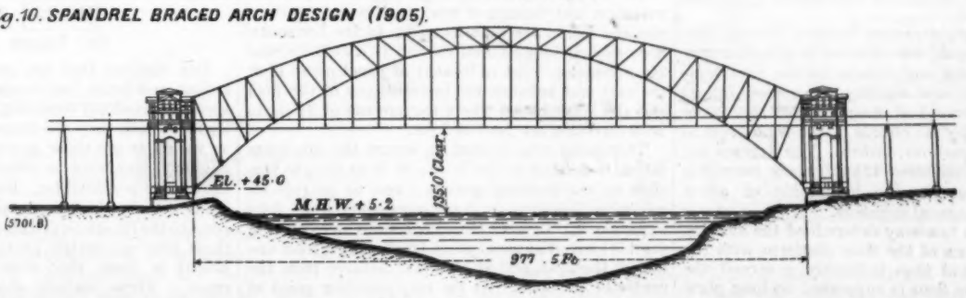


Fig. 10. SPANDREL BRACED ARCH DESIGN (1905).



(5701.B)

a crescent arch truss and a spandrel braced arch truss (see Figs. 9 and 10, annexed), both two-hinged, both of the same length between end pins, both with suspended floor systems, both with massive ornamental end piers both for the same loads and specifications as previously considered, and both to be made of carbon steel. The spandrel braced trusses were finally adopted with reverse curves at the extremities (see Fig. 3, page 170) of the top chord to improve the outline and give better opportunity for portal bracing.

PRINCIPAL DATA.

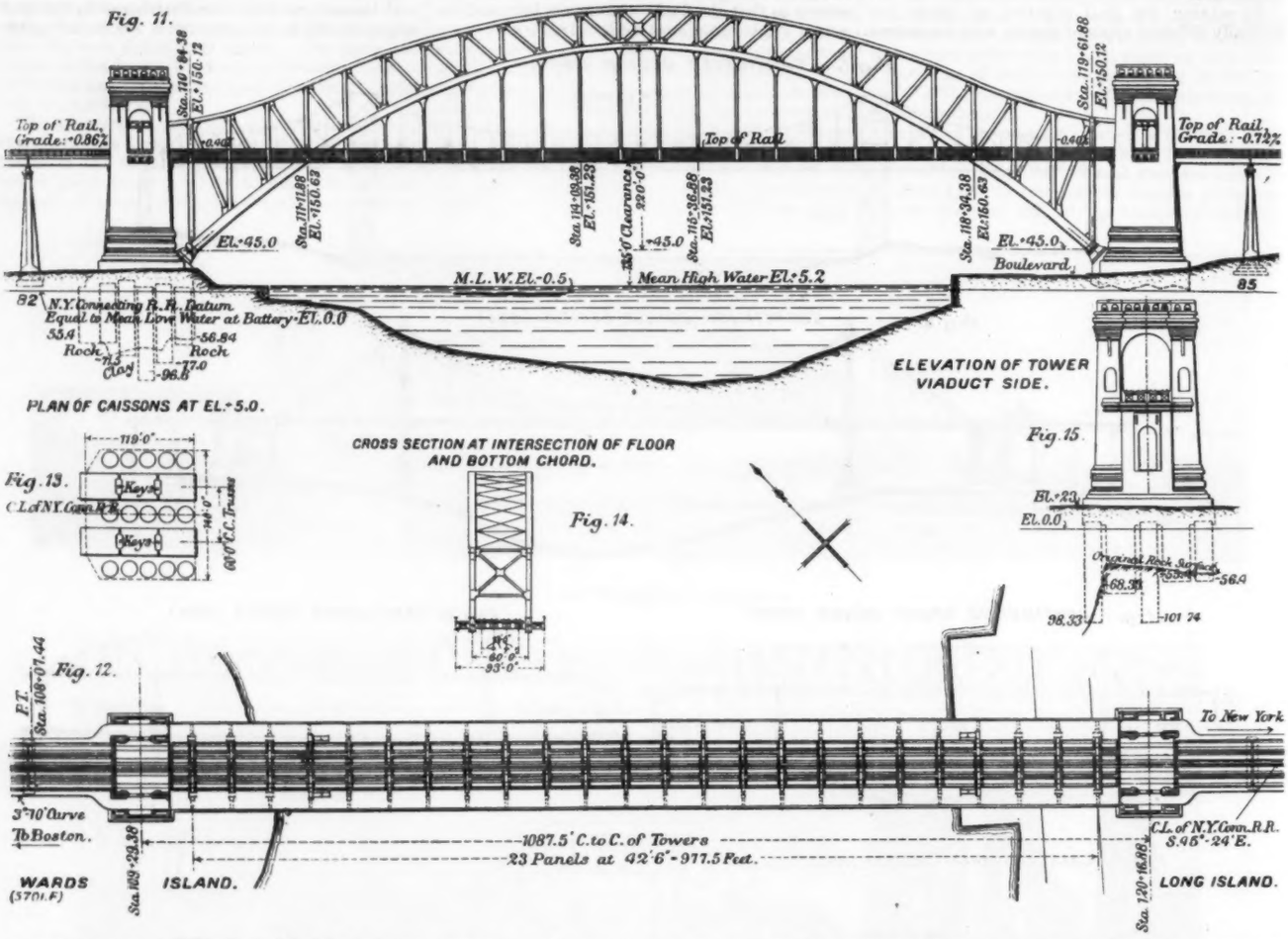
Span: 1,016 ft. 10 in. between tower faces.
Span: 995 ft. 1⅝ in. between centres of bearings.
Span: 977 ft. 6 in. centre to centre of end hinges.
Height of arch from centre of end hinges to centre of top chord; 140 ft. at ends; 260 ft. at centre.
Height of arch above mean high water, 310 ft.
Height of towers above ground, 240 ft.
Clear height above mean high water, 135 ft.

channel and indirectly fixed the approximate span.

When the span is uniformally loaded throughout, the bottom chords are independent arch ribs with their panel points in parabolic curve of the stress diagrams. This condition is assured by the construction of the trusses as 3-hinge arches under dead load; the centre joints of the bottom chords at the crown of the arch acting as the middle hinges. The rise of the centre line of the bottom chord is 220 ft., giving a ratio of rise to span length of 1 to

HELL GATE BRIDGE, NEW YORK; ARCH SPAN.

MR. GUSTAV LINDENTHALL, CHIEF ENGINEER.



4·5 which gives nearly or quite the maximum economy of weight in the structure. The depth of the trusses varies from 40 ft. 2⅛ in. at the centre, about one-twenty-fourth of the span, to 140 ft. at the ends, an amount required for satisfactory portal bracing above the track. Both top and bottom chords are made with straight sections between panel points, deflections there being so small as to give the general outline an appearance of regular continuous curves.

The width of the structure between trusses, one-sixteenth of the span, was required to give clearance for the four tracks, and suffices for the considerations of stability and rigidity. Increased lateral rigidity and economical floor construction were secured by making the chords of the wind truss in the floor 93 ft. apart on centres. The trusses are divided into twenty-three 42½-ft. panels providing the most efficient average inclination of about 45 deg. for the diagonal members.

The navigation headway determined the location of the intersections of the floor platform with the bottom chords and thus indirectly governed the span length. The floor is supported on long plate girder floor beams at panel points of the trusses; four of which at each end of the span are rigidly framed into the vertical members of the trusses, and the remainder are suspended by verticals from the top chords. To the floor beams are web connected eight lines of railroad track stringers braced together in pairs, each pair carrying the ballasted track in a concrete trough. There are also four lines of sidewalk stringers heavy enough for a trolley car service and two lines of lattice hand rail girders at the extremities of the floor platforms, the bottom chords of which are identical with those of the lateral system trussing the floor platform. The chords are connected by diagonal members making up the wind truss. At each of the two intersections of the floor platform with the main trusses there is a brakeing girder to transmit the longitudinal stresses from brakeing and traction to the main trusses and thus prevent transverse deflection of the floor beams.

As the skewback hinges are fixed, temperature variation and changes of load produce only vertical rise and fall in the arch trusses. In the horizontal floor system longitudinal motion is inevitable, and the expansion joint is located at panel point 12 at the east end between the intersections of the floor and the lower chord where movements of 2½ in. in both direction are provided for.

This point was located to secure the minimum lateral deflection in the floor; to be as near as possible to the brakeing girders; and to provide for minimum bending in floor suspenders from floor expansions. To meet these conditions an expansion joint is located at panel point 12, six panels from one end of the span and at an equal distance from the centre of the span. At the corresponding point at the west side of the centre the wind chords are cut and the floor laterals are rigidly connected to the centres of the floor beams. This arrangement divides the horizontal floor truss into a three-span cantilever arrangement, the suspended span delivering its reaction to the cantilever arms by the fixed connections of the diagonals at one end and by the sliding bearing at the other end, reactions being transmitted to the bottom chord lateral system and thence to the skewback bearings of the main arch. At the end of the bridge the reactions are transmitted to the sway frames between the vertical end posts and thence also to the skewback bearings. The longitudinal forces are transmitted to the brakeing girders at both ends and the stringer connections to the floor beams are strong enough to safely resist them.

(To be continued.)

RECENT MACHINE TOOL DEVELOPMENTS.—No. III.

By Joseph Horner.

The outlines that are imparted to the beds of lathes, and lathe bed types in other machines, in their longitudinal direction, and the forms of the legs on which they are supported, reveal differences as varied as are those given to their cross-sections. Rigidity, resistance to torsion, and to longitudinal flexure are provided for. But, in addition, there are many details which lie outside of these, and correspond to the functions of different designs of machines, these now embodying provisions that were wholly absent in those that were standard a few years since. These include shapes, outlines, fittings, proportions, provisions for numerous operating mechanisms, for the storage of tools, for collecting waste lubricant, and its recirculation. These differences and developments have multiplied in recent years with every advance in improved designs. In the older standard lathes and lathe types no provision at all was made for catching waste lubricant, and though very little was used, mess accumulated. Cupboards for tools were not considered, but beds and tables were littered with a miscellaneous collection. Legs were skeleton-like, generally narrower at the top than at the foot, and

located at the ends of beds, leaving the bed a long beam liable to flexure. The early form of bed, and presumably to be styled even now the standard is straight, except for a gap, and is supported on stiff legs that fulfil no secondary function. This design is disappearing both in regard to the gap and the legs.

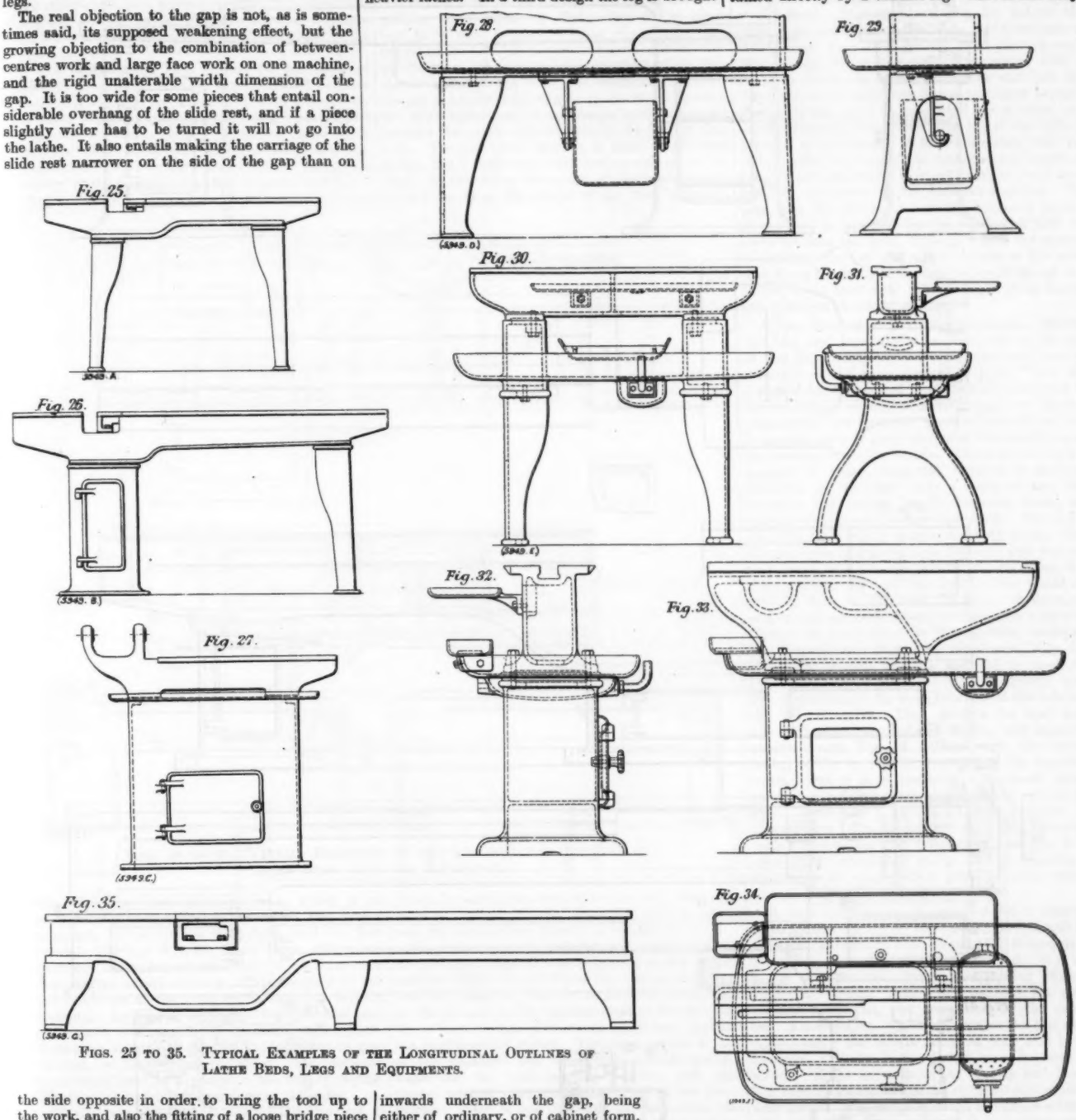
The real objection to the gap is not, as is sometimes said, its supposed weakening effect, but the growing objection to the combination of between-centres work and large face work on one machine, and the rigid unalterable width dimension of the gap. It is too wide for some pieces that entail considerable overhang of the slide rest, and if a piece slightly wider has to be turned it will not go into the lathe. It also entails making the carriage of the slide rest narrower on the side of the gap than on the side opposite in order to bring the tool up to the work, and also the fitting of a loose bridge piece in the gap when the carriage has to be supported close to the headstock. The lead screw and feed-shaft must be kept sufficiently clear of the gap to permit of the swing of work of maximum diameter. The objection to a gap of unalterable width is met by the movable-gap design, in which an upper bed slides along a lower one. It is a good scheme, but is not extensively favoured because the present tendency is to put face work on regular face lathes, and between-centres work on lathes without gaps.

The existing gap lathes are, however, still numerous, and there is some demand for them, especially in shops that handle a general class of work. They include two principal forms. One is that in which the metal is brought down beneath the gap to compensate for that cut away, and terminating at the leg under the headstock. The other has the metal carried down to form the leg or a portion of it, this being the usual design of the heavier lathes. In a third design the leg is brought inwards underneath the gap, being either of ordinary, or of cabinet form.

A common design for light gap lathes is shown by Fig. 25. The bed is deepened under the gap, and the leg at that end is brought along to afford support there just where it is wanted, leaving the headstock to overhang slightly. The leg at the other end is also brought inwards. The distance between the legs lessens the chance of flexure occurring to the bed by comparison with the older standard design, and this, therefore, is in growing favour. The gap piece partially fills the space, resting on the bottom and on a step or shoulder. The beading on the top flange of the legs is a trifling detail, but it avoids having to make a flush fit between the flange of the leg and its facing on the bed, and the appearance is neater than that of square edges.

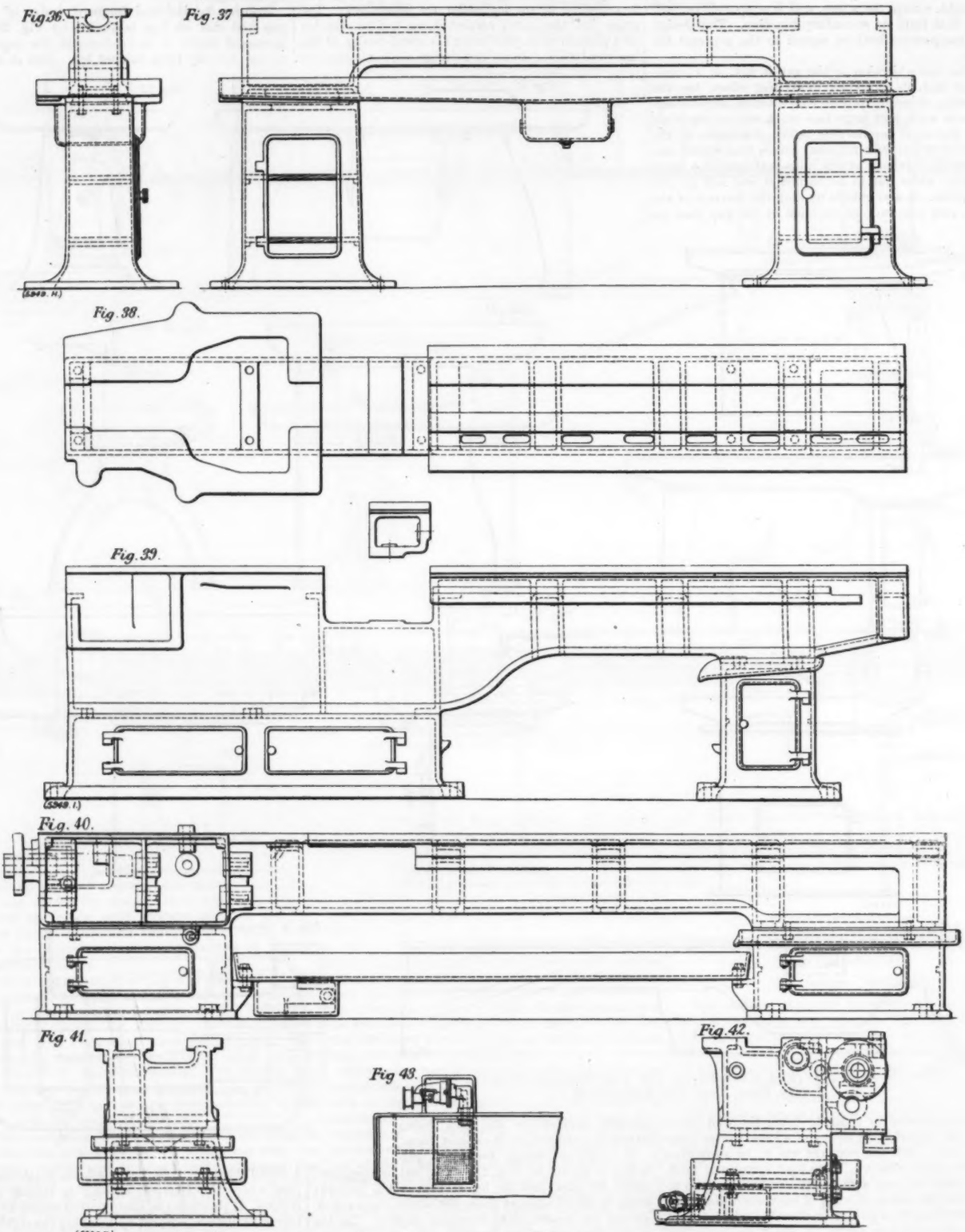
Another typical and frequent design of a small gap bed and its legs is shown by Fig. 26. The increased depth of metal beneath the gap is sustained directly by a cabinet leg. This is not only a useful store for tools, but it affords ample support just where the heaviest cutting at largest radius is done. It shortens the unsupported length between legs, still further lessened by bringing the right hand leg inwards. The bed is slightly tapered, also, corresponding with the reduced stresses away from the headstock. The filling-in gap piece is similar to that in the last example, as is also the beaded finish at the top of the legs.

A neat compact design for small lathes is seen in Fig. 27. The bed and fast headstock are one casting, a practice which is adopted in several of the large



FIGS. 25 TO 35. TYPICAL EXAMPLES OF THE LONGITUDINAL OUTLINES OF LATHE BEDS, LEGS AND EQUIPMENTS.

RECENT MACHINE TOOL DEVELOPMENTS.



FIGS. 36 TO 43. TYPICAL EXAMPLES OF THE LONGITUDINAL OUTLINES OF LATHE BEDS, LEGS AND EQUIPMENTS.

lathes of all-geared head design. In some of these cases, though not in this example, it complicates the work of moulding. But jointing and bolting are avoided and improved rigidity is claimed. In small lathes, cost is slightly reduced. A single cabinet leg occupies nearly the length of the bed, and it is entirely surrounded with a waste-oil tray. The structure is stable and cheap.

Figs. 28 and 29 illustrate the lower portion of the framing of a Pratt & Whitney Lincoln miller, the legs and bed of which are built on the lathe type. It includes also provision for the collection and recovery of waste lubricant. The legs are wide at the top, and thus sustain the bed along a good distance away from the ends. The tray for waste

lubricant is cast with the bed and extends to a good width at back and front to receive all splash. Its bottom slopes very slightly to the centre, whence the lubricant falls into a vessel suspended on trunnion brackets bolted to the bottom of the bed. A grid or strainer keeps the chips back. The vessel is emptied by tipping its contents, which escape by the lip. To maintain it in a vertical position, it is suspended slightly out of centre, Fig. 29, and has a couple of horns which abut against the front edges of the brackets.

The illustrations, Figs. 30 and 31, are those of the framework of a small hand-operated capstan lathe. It includes the actual bed, with a tool tray, a waste lubricant tray or trough cast with the bed supports, to which the legs are bolted, these being brought within away from the ends. The headstock, capstan rest, and a cross slide fit the bed by outside square guiding edges. The bed is boxed and has a single cross girt. A broad tray is bolted to the front, at the ends of the bed for bolting to the leg favour stability. A beading round the top of the leg breaks joint neatly. The universally-curved outlines of the leg, its foot, and the tray have a pleasing appearance.

Passing to the designs of some of the larger lathe framings, Fig. 35 illustrates a typical example of a moderately heavy gap bed of 10-in. centres. The bed is very wide for its depth—21 in. wide over the guiding vee'd edges, by 12 in. deep. The three legs have wide abutment areas where they are bolted to the bed. In the end view (not given) they are spread at the base to twice the width of the face that is bolted to the bed. The weakening effect of the gap is amply compensated by the metal beneath it. With higher centres and deeper beds, the metal beneath the gap is utilised to form the foot at that end. The gap piece here, as is usual in all large lathes, has a bearing at each end as well as on the base. In this lathe the centre of the heads stands back 2 in. from the centre of the bed, a feature

Fig. 44.

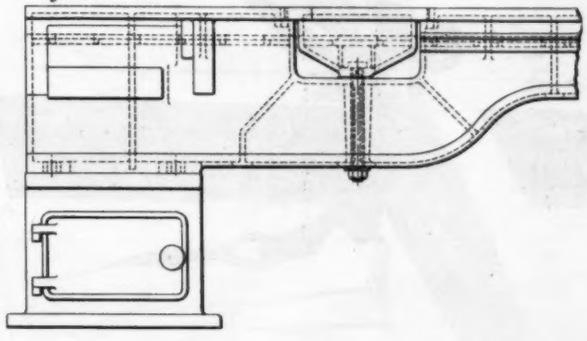


Fig. 45.

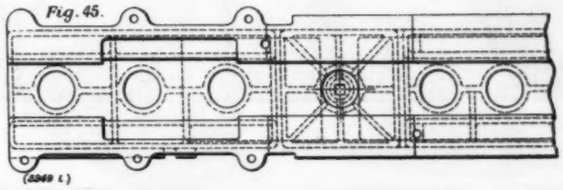
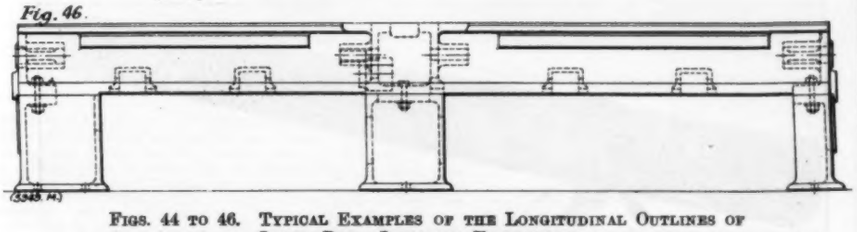


Fig. 46.



FIGS. 44 TO 46. TYPICAL EXAMPLES OF THE LONGITUDINAL OUTLINES OF LATHE BEDS, LEGS AND EQUIPMENTS.

Fig. 31. The waste-lubricant tray, which is of good length and width, is cast with two boxed standards bolted to the bed above and the feet below. The legs fit with broad faces. They are narrowed below, but spread widely in the transverse direction to afford stability. The flanging of the bed outwards at the ends on its supports favours stability. Lubricant and chips fall into the tray underneath the location where cutting takes place. A strainer in the tray permits the lubricant to pass through, while retaining the chips. The lubricant is conveyed back by a pump to the supply piping. The tray is lifted out for removal of the chips.

Having several features resembling the last is the framing of a Herbert shaving lathe, shown by Figs. 32 to 34. It is a specialised tool, a satellite to the turret lathe, and carries only a headstock and a saddle with a cross slide rest having two tool posts. Since the bed is short, a single cabinet leg supports it. Chips and lubricant fall down into the waste oil tray which is a separate casting interposed between the bed and leg. It is provided with a pocket, seen in each view, from which the lubricant is drawn by a pump bolted down on the facing in the small pocket seen at the left-hand end, and used again. A strainer is fitted over the pocket. A tool tray is attached at the front of the bed. The spreading feet or lugs which, in association with the wide bed, brings the stress of cutting on large diameters over or nearly over the front shear instead of outside it.

The lathe type of bed and legs appears in the Webster and Bennett double-headed profile milling machine (Figs. 36 and 37) of the horizontal design. The fact that the headstocks and the work-heads are duplicated at the opposite ends of the bed, and that a large volume of lubricant is required, explains the modifications shown. The cross-section is that of the standard bed with vee'd outside guiding edges for the work-carrying saddles, and with square interior edges for the tongues of the headstocks. There is one cross-girt at the centre, but the shears are tied together under the locations of the milling cutters with solid-plated webs that receive the lubricant and chips, and direct them into the long trough that encircles the bed. The bottom of the trough slopes to a centre circular receptacle covered with a perforated wrought-iron plate which keeps the cuttings out of the central well. Two cabinet legs afford ample support. These measure 15 in. by 8½ in. in plan, and stand 2 ft. high. The bed measures 7 ft. long, is 7½ in. wide over the vee'd edges, and 7½ in. deep.

Figs. 38 and 39 represent the framework of a lathe of 9-in. centres, designed for high-speed work by the Selson Engineering Company, Limited. Although it is of only 8½ in. centres, it is a remarkably stiff design, illustrating vividly the difference the use of high-speed tools makes in the demands to resist rigidity and flexure. The bed section is solid-topped between the ways. It has cross girts of box section. It is wide, measuring 16 in. over the shears, and the saddle fits to a narrow guide at the front. Slot openings, Fig. 38, behind the guide way, are cast for the chips and lubricant to fall through to a tray on the floor (not shown). The cabinet leg at the right is provided with a shoot to direct the waste from that end into the tray. The metal under the gap is continued beneath the headstock, and is supported by a very long cabinet leg with two doors. The leg at the right is brought to a distance of 12 in. inwards from the end, greatly shortening the unsupported length of bed. These legs stand vertically on the front door face, but are spread at the back for stability. The plan, Fig. 38, illustrates how the left-hand portion of the bed is widened for the headstock and cut away to clear the gears through which the spindle is driven. One of the minor details is the strip cast along the front of the bed to resist the upward thrust of the feed rack. The filling-in piece for the gap is shown above its opening.

Again, there is but scant resemblance between the bed and legs shown in Figs. 40 to 43—one of the Smith and Coventry designs—and the old standard of the same centres, 10½ in. This, also designed for high-speed work, is fully equipped for screw-cutting, sliding, and surfacing, but the feed shaft, as is now frequent, goes in front of the bed. It has the narrow guide that was illustrated among the sections of the last article. Two long cabinet legs support it, these being well splayed at the back. Brackets on the legs carry a waste-oil tray that occupies the entire length between them, and extends well beyond front and back. The leg at the right-hand end is surrounded with a tray which directs waste lubricant from that end into the long tray beneath. At the left-hand end there is a clear opening through the bed for the waste discharged there to fall into the tray. A deep well at this end has half its area covered with a strainer, whence the pump shown in Fig. 43 draws its supply. The bed measures 20 in. over the shears, 13-in. deep along the central portion, and 15½ in. deep over the legs. The cross-girts are of boxed form. The disposition of the shaft bearings at the left-hand end is instructive. They provide for lead screw and feed shaft carrying and driving boss supports; compare with Fig. 42. These with the interior coring of the bed, rather complicate the moulder's work. But it is in harmony with much present practice to cast as much as possible in one, and so avoid bolting on a number of loose brackets and attachments. The principal risk is that associated with the drawing and warping of castings, to be avoided by equalising metal, and eliminating or lightening all chunks that interfere with uniform shrinkages of adjacent parts.

A very stiff design of gap bed for a standard lathe of 8-in. centres by Messrs. J. Archdale and Co., Limited, is shown by Figs. 44 and 45. It is equipped for sliding, surfacing, and screw cutting. It is wide—14⅜ in. over the shears, the guiding edges of which are square. The metal beneath the gap is continued parallel, and supported by the cabinet leg. A similar leg, but taller, carries the bed at the right-hand. The bed is rendered very stiff by the ribbings, and by being plated over between the shears. Holes are cast in the plating and bossed. The metal beneath the gap is stiffened in the plating and bossed. The metal beneath the gap is stiffened with ribs. The filling-in piece is held down with a central bolt that passes through a deep boss in the bed. The upward pressure of the feed rack is taken against a shouldered strip.

Fig. 46 represents the bed of a Whitworth double-axle turning lathe, a design in which the driving headstock occupies the centre of the bed, with the loose poppets movable to right and left. The main driving pulleys and gear are located at the left-hand end, which explains why a heavy box leg is used here instead of the light leg at the right hand. A similar box leg is inserted under the massive headstock. The bed has boxed cross girts

METAL CONSTRUCTION OF AIRCRAFT.

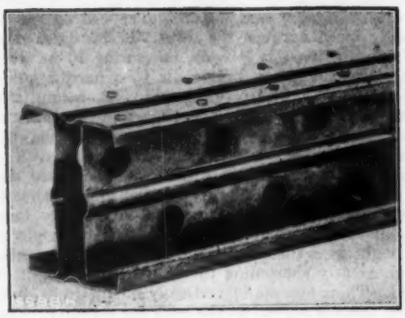


Fig. 18.

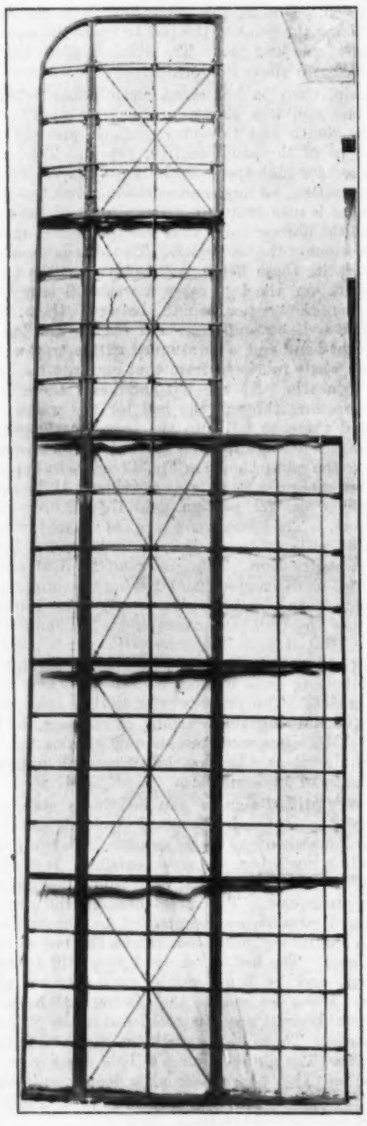


Fig. 19.

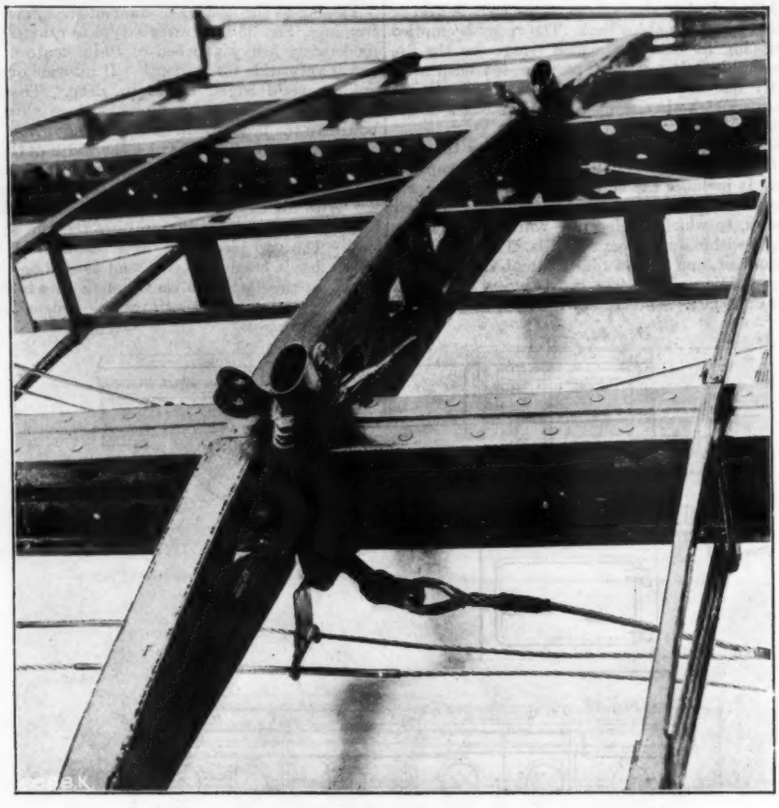


Fig. 20.

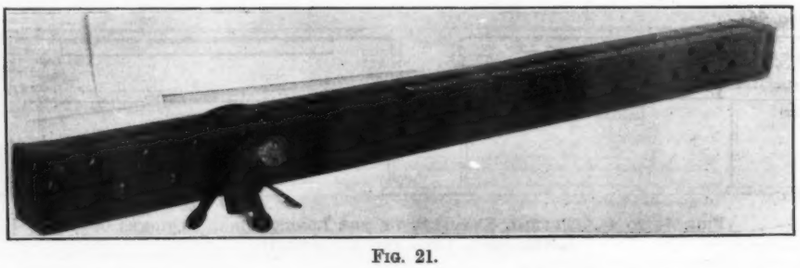


Fig. 21.

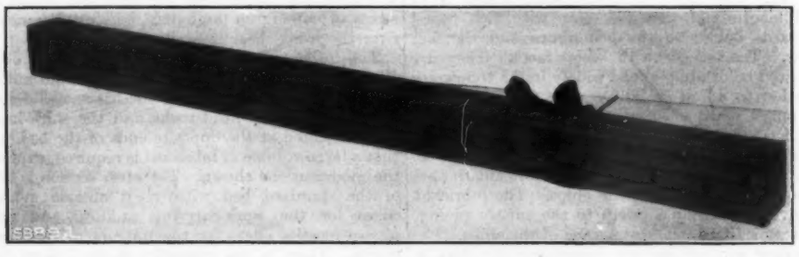


Fig. 22.

that extend to the underside of one shear, but are curved low down on the other in order to clear the lead screws which lie within the bed to one side, since the lever mechanism of the clasp nuts occupy a central position. A wide bed is, therefore, necessary, and apart from that, the employment of double cutting tool holders at back and front require a wide bed. The bed, 13 in. deep, is 17 in. wide over the main portion, and, of course, the width is increased at the centre to receive the driving-head and mechanism. The tool saddle bridges across the bed fitting it with vee'd guiding edges, each with a take-up strip.

The Mining Institute of Scotland.—By the kind permission of the Coltness Iron Company, Limited, the council have been enabled to arrange an excursion for the members of the Institute to Blairhall Colliery, East Grange, Fife, on the 16th inst.

METAL CONSTRUCTION OF AIRCRAFT.*

By A. P. Thurston, D.Sc., F.R.Aë.S., F.R.Met.S., M.I.A.E.

. (*Continued from page* 144.)

The spars previously described have been made from rolled strip. A second alternative is to construct spars from metal sheet which can be obtained in lengths up to 10 ft. from firms such as Sankey's and Firth's. Valuable and useful work has been carried out in developing this form of construction by Colonel J. A. Cole, Mr. Nibblet,

* Paper read before the Royal Aëronautical Society, on May 14, 1919.

and Mr. Horsfield, of Humber's, Limited. An original design from which this firm's design was developed was very courteously placed at their disposal by Captain Green, of Siddeley Deasy. A drawback to all the designs heretofore described is the difficulty in applying them to existing machines without re-designing the fittings. Messrs. Humber have produced a design which solves this difficulty and they constructed a metal machine in record time. The first section, Fig. 18, was made of 25-gauge 30-ton steel sheet for both flange and web. The width of the flange was 2 ins. and a stiffening bead or corrugation was rolled in the centre of the flange throughout its length. The web was lightened by circular holes punched on either side of a longitudinal bead or corrugation in the centre of the web and slightly

Fig. 23.

Fig. 24.

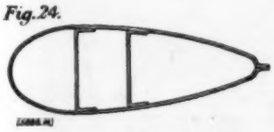


Fig. 25.

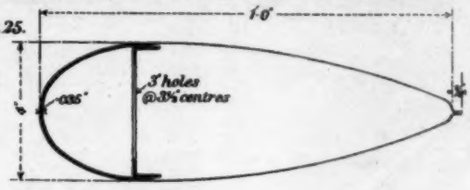


Fig. 26.

smaller than the flange. This section is the same in all overall dimensions as the standard Avro spar. The spar was made up of four lengths joined together by staggered lap joints, three of these lengths being identical, the fourth being tapered to suit the outer extremity of the wing. The webs and flanges were pressed to shape in a stamping machine. The ultimate section decided on was similar to the above, but of 35-ton steel with the flange and web of 26-gauge. Fig. 19 is a photographic illustration of the first plane built up of metal spars and tested at Farnborough, where it successfully withstood the required load. Fig. 20 shows in detail the method of attaching the internal bracing and strut sockets and wiring plates to this wing. Standard Avro fittings are used throughout. The interplane strut fittings are raised from the spar by means of a very light steel box. The spar is stiffened to take internal bracing by means of a pressed steel cross transmitting the strain radially from the transverse bolt to the flanges and webs of the spar. The spar itself is stiffened to take torsional strain by means of aluminium distance pieces, the webs being connected by means of aluminium rivets passing through the distance pieces. The thrust of the interplane struts is taken on an aluminium pillar passing radially through the spar directly under the strut, the pillar being pierced by the transverse bolt which passes through pressed steel crosses. These crosses distribute the load over a large area of the spar. Figs. 21 and 22 show another method of attaching the fittings which is self-explanatory. The specimen has been tested to destruction and shows the failure of the flange in the centre.

The solution of the strut problem is much simpler than that of the metal spar. There are several principles which must be kept in mind in tackling the problem. Since the external shape must be such as to offer the minimum head resistance, we are limited to a streamline shape. If a steel tube is used it must obviously be provided with fairing back and front, which does not contribute greatly to the strength, but adds considerably to the weight; moreover, steel tubes of high quality are expensive. It follows that steel tubes are not the best construction for this purpose except in non-exposed places, where stream-lining and diameter are of no consequence. If the exterior of the metal strut is to be streamline, the moment of inertia about the minor axis will be much greater than about the major axis. This does not lead to an efficient disposition of the metal. Moreover, the front and rear edges are sharply curved and hence self-supporting, whereas the sides are only slightly curved. The principle therefore to strive after is the provision of more metal at the sides and rigid supports for the sides. This problem has been very successfully solved by Mr. C. A. Llewelyn Roberts, of the Birmingham Guild, and by Messrs. Sankey, from designs courteously placed at their disposal by Lieutenant Commander Wylie. Certain designs are stronger and lighter than the best spruce or steel tube struts. Fig. 23 shows the Birmingham Guild strut No. 4. This was designed to be constructed in two halves, the nose of the strut being designed to take the whole load. This

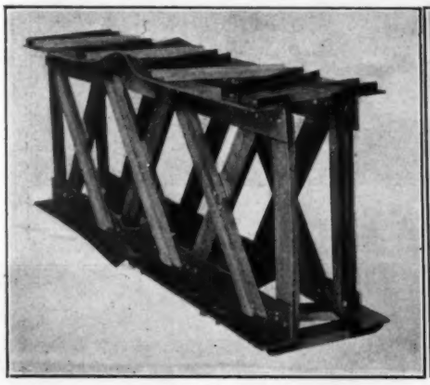


FIG. 27.

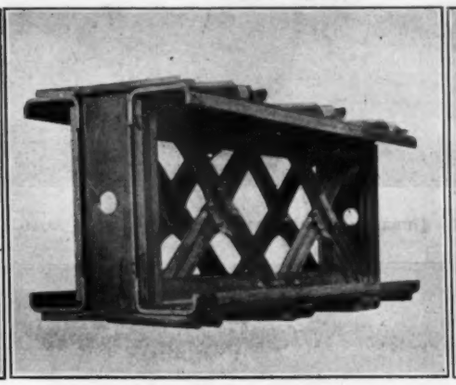


FIG. 28.

FIG. 29.

Fig. 30.

nose was made in high tensile steel with a cross-piece of the same material connected by electric spot welding. The tail fairing was made of aluminium. The joint between the fairing and nose was made with a tinsmith's folded joint well hammered down. This strut weighed complete with end fittings 3 lb. 1¼ oz., thus bringing the weight below that of the lightest Avro wood strut. On test, it supported a load of 0·75 ton on 66-in. centres, being 20 per cent. stronger than the Avro wood strut of nearest weight, although the wood in the latter case had a Young's modulus of $1{\cdot}8 \times 10^6$ lbs. per square inch. Fig. 24 shows Birmingham Guild strut No. 5, which is extremely simple in construction. It is composed of three units only, a shell and two diaphragms, the extra one being added in this case to give greater rigidity and strength. The production of this strut required no hand labour. The units are all blanked out and formed up in presses, the units themselves being jigged together for spot welding, and the whole of the electric spot welding being done in three-quarters of an hour. The actual cost of this strut in production is stated to be half that of wood. Its weight is 3·15 lbs. as against 3·25 lbs. for the wood strut. Its failing load on 60-in. ball centres is 0·77 ton, as against 0·475 ton for the wooden strut.

Figs. 25 and 26 give outline particulars of two types of stream line metal struts by the Birmingham Guild which are well suited for large machines. The double-web type of construction, shown in Fig. 26, gives greater stiffness for a given width and weight when made to a given streamline section, say of 3 to 1, than any other known type made to the same streamline section. It is therefore stronger. These types of struts are suitable for lengths up to 25 ft. or over, and there is no limit to the load they can be designed to carry. Hollow wooden struts made of grade A spruce are known to be unsuitable for tropical use. Moreover, for a given width, weight and length, hollow wooden struts have been found to be about 50 per cent. heavier than the double strut described above. A round steel tube with wood and fabric fairing is about 70 per cent. heavier than these struts. Apart from this, solid drawn steel tubes of the sizes necessary for the largest machines are unobtainable.

All the previous descriptions have especially related to steel constructions, but many of the constructions are suitable for duralumin. The problem of the duralumin machine of various types has been tackled successfully by Commander Craven and Messrs. Pratt and Temple, of Vickers, Limited, starting from a suggested design courteously placed at the firm's disposal by Professor Lea, of Birmingham University. In designing the most economical braced girder to withstand a certain definite system of loading, there are usually three points which have to be considered if the highest efficiency is to be obtained. These are: (a) The ratio of the overall depth of the girder compared with its pin-jointed length. If the girder is made very deep the weight of the bracing becomes excessive, while on the other hand if made too shallow, unnecessary weight has to be put into the main flanges or members. The maximum depth of the girder is usually limited by the section of the plane. (b) The pitch of the bracing. If this is too great, unnecessary weight has to be put into the main flanges. If the pitch is too small the weight of the bracing is unnecessarily heavy. (c) The properties of the actual section used for the main flanges or members. If the member is made very thin it fails at a low stress by secondary flexure, while on the other hand if the flanges are made very thick compared with their width, the radius of gyration for a given sectional area is necessarily small in proportion to the pin-jointed length, *i.e.*, to the pitch of the bracing, and hence the member also fails at a low stress.

The effect of varying each of the above items has been very carefully investigated and general data obtained which enables not only the strength of any particular girder to be accurately calculated, but also the girder to be so proportioned as to allow the maximum efficiency, from the point of view of strength for weight, to be obtained. In addition to the above three points there is another one (d) which has been investigated and has been found may be neglected. At first when the subject was approached it was thought that the strength of the small elements between points of attachment of adjacent bracing would depend on the stiffness of the bracing. Experiment has proved that the increase of strength to be obtained by this means unnecessarily increases the weight of the bracing and is not economical, and that the strength of the individual main member or flange may be calculated, by Confidential Information Memoranda 720, as a strut with pivoted ends and of a length equal to that between the centres of the bracing attachment. If the bracing were infinitely stiff and were attached to the main member in an absolutely rigid manner, the pin-jointed length of the elementary strut would be half the pitch of the bracing; on the other hand, if the bracing is without stiffness, or if only attached by a single rivet to the main member, then the pin-jointed length is taken as equal to the pitch of the bracing. The exact effect of the stiffness of the bracing on the pin-jointed length of the main member can be actually calculated in any case. C.I.M. 720 has been brought up to date and

METAL CONSTRUCTION OF AIRCRAFT.

NOTE - WIRING OF ALL SOCKETS IN WAY OF LIFT WIRES (REMOVED AT THIS JOINT AFTER FAILURE)
NOTE - CRUSHING OF THIMBLES CAUSING EARLY DEFLECTION
NOTE - TWIST OF BOLT AND DRAG STRUT

Fig. 31. Duralumin Spar after Testing with a Load Factor of 10·7.

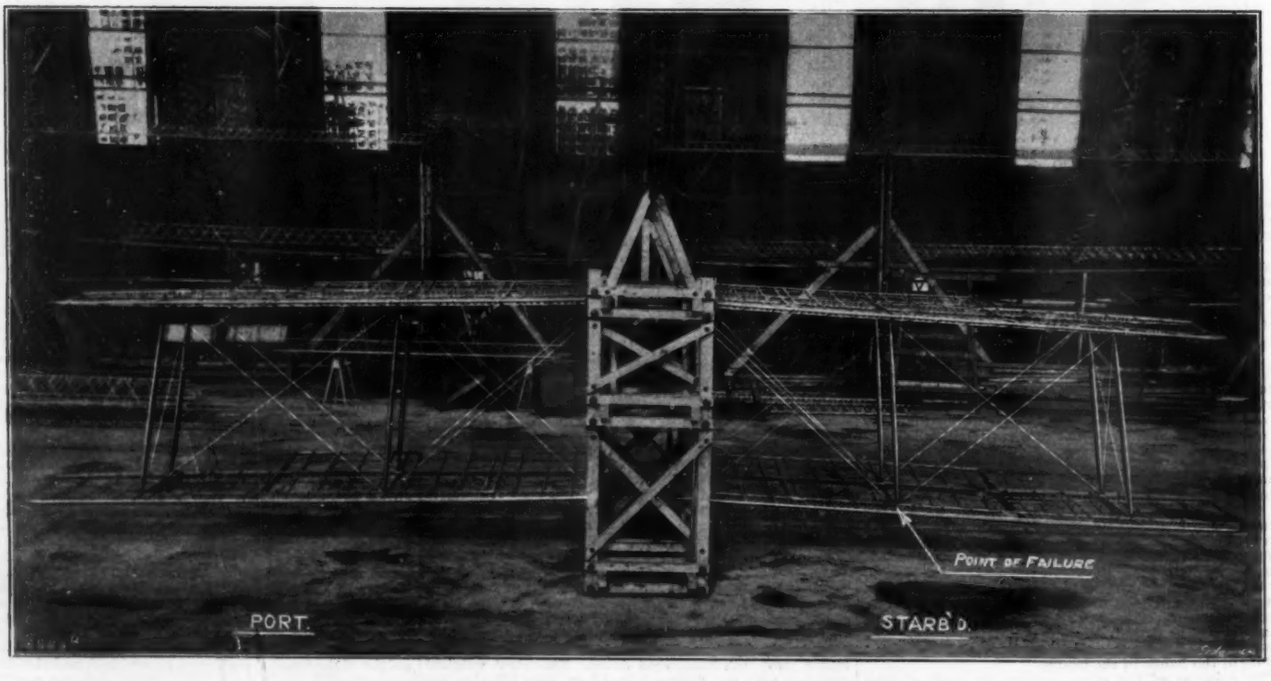


Fig. 32. Front View of whole Structure after Test to Destruction.

amplified by a large number of experiments on flanges of various thicknesses.

Having fixed on the dimensions in (*a*), (*b*) and (*c*) above the strength of the girder as a whole is next considered. The strength of the individual member, usually the flange between points of support of the bracing, is taken as the limiting stress at the centre of the girder, and then the failing load at the ends of the girder is calculated by the Alexander strut formula which has been proved to give results in agreement with experiments. The Alexander strut formula is as follows :—

$$\frac{n}{k^1} - \frac{l}{k} = A\frac{\delta}{k} \times \frac{\sqrt{p}}{f - p},$$ where

p is the intensity of stress in tons per square inch on the ends of the strut at failure.

f is the limiting fibre stress at the centre of the strut at failure. It is approximately equal to the limiting fibre stress under conditions of pure bending.

$\frac{n}{k^1}$ is equal to $\pi \sqrt{E/p}$. If Euler's curve for the material is plotted. *i.e.*, $p = \pi^2 E/(l/k)^2$ then l_1/k_1 is equal to the horizontal distance out to this curve at a height corresponding to the failing pressure p.

$\frac{\delta}{k}$ is the ratio of the distance of the extreme fibre from the neutral axis, to the minimum radius of gyration, measured in the direction of the latter.

A is a constant which equals $2c\sqrt{E}$, where c is the ratio of the equivalent eccentricity to the radius of gyration, usually taken as 1/10 for ordinary struts and 1/20

METAL CONSTRUCTION OF AIRCRAFT.

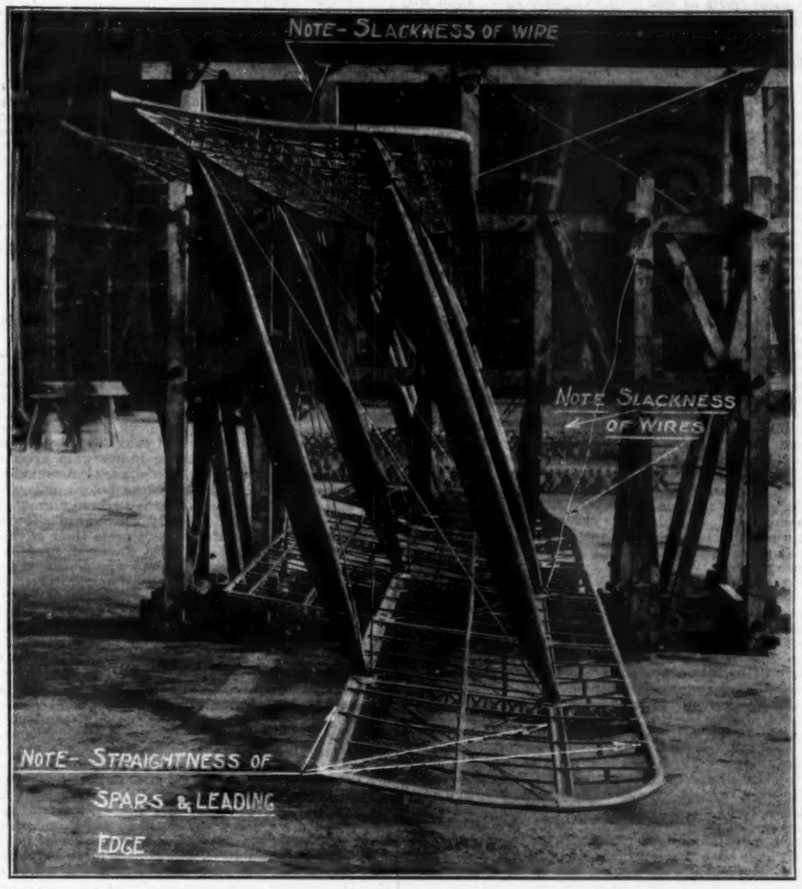


FIG. 33. SIDE VIEW OF WHOLE STRUCTURE AFTER TEST TO DESTRUCTION.

for especially straight struts. The value of $A = 2c\sqrt{E}$ is found by experiment for duralumin braced girders to be about 10.

The thinner the flanges of the angle, that is, the higher the value of s/t, where s equals the thickness of the flange, and t equals the width, the lower is the limiting stress at failure at the centre of the strut. This reduction in the limiting stress in the thinner members is, of course, due to the effects of failure by secondary flexure. By plotting the failing loads of a series of experimental beams having varied thickness of angles against s/t for the angles a simple investigation shows the most efficient value of s/t to use with a fixed pitch of bracing. With plain angles the limiting stress for sections for which $s/t = 30$ is only 7·8 tons per square inch. On the other hand, for values of $s/t = 7$ the limiting stress is 17·5 tons per square inch. The most economical values of s/t for plain angles appears to be between 6 and 8, and, in any case, should not exceed 10.

A photograph of a typical specimen of the series of girders for a large machine built up to investigate the relations of s/t and limiting stress for plain angles is reproduced in Fig. 27. A similar series of girders were constructed with a modified section for the main members, as shown in Fig. 28, which is a typical specimen. In general it was found that lipping improves the thin section, while on the other hand, the failing stress in the case of the thicker sections is only a little higher. For instance, the limiting stress for sections for which $s/t = 30$ is 11·7 tons per square inch as against 7·8 for plain angles. Whereas for values of s/t of 7 the limiting stress of the lipped section is only 17·5, i.e., the same as the plain section. Hence there appears to be no advantage in lipping the sections. In order to obtain the most economical design it is obvious that the dimensions of the main members will require to be varied from place to place. Therefore at the centre of a large machine, in view of the fact that duralumin cannot efficiently be solid drawn in sections thicker than 0·2 in., it may be found that the size of the angle members required become too great to permit them to be solid drawn. It therefore becomes necessary to modify the design. One such modification is shown in Fig. 29. In this design plain angles are used to which are riveted longitudinally corrugated plates. To prevent local buckling of the plates the pitch of the rivets should not exceed 15 times the thickness of the plate.

With regard to bracing it has been found that the best type of bracing is quite different from that used in airship girders. In the case of airships, since the shear is small, and the main members are of light section, with a large pitch for bracing, it follows that a rigid bracing in the plane of the members is economical. Moreover, discontinuous bracing gives a further economy. In the case of aeroplane girders the main members are much heavier and the value of L/K between bracing points so much smaller that the increase of strength to be gained by providing stiffening bracing is not justified. Moreover, since the shear is large it follows that the bracing should be practically continuous to obviate the introduction of local bending moment; further, the Zeppelin type of bracing is inadmissible as this would necessitate double bracing. The problem of the suitable attachment of the fittings presents as great difficulty in the case of large machines as in small ones. It is of such importance that the design should be modified in the first instance to enable this to be done economically.

In calculating the strength of a spar it is necessary to make allowance for the extra stresses induced by the bending moment introduced by deflection. For wooden spars it is usual to use Perry's formula for a strut subjected to a bending moment. The bending moment due to the lateral load is then multiplied by $P\,e/(Pe - P)$ to obtain the equivalent bending moment, where Pe = Euler's crippling load and P = end load in ebs. This makes allowance for the additional stresses placed upon the spar due to the bending moment obtained by the product of end load times the deflection, and gives fairly satisfactory results for spindled wooden spars. It cannot be used, however, for calculating the strength of metal construction, experiment having proved that the deflection is of the order ten times that given by Perry's formula. The deflection of metal spars calculated in the following way has been found by Mr. Temple to agree with practice. From the ordinary theory of beams the deflection in the centre of a girder under side loading is equal to

$$\delta = \frac{5}{48}\,\frac{L^2 M}{E I}.$$

Where δ is the deflection in inches.
L is the length between the supports in inches.
M is the maximum bending moment in in.-lbs.
I is the moment of inertia in inch units about an axis perpendicular to the direction of loading.
E is Young's modulus for the material of the girder which as a result of bending tests on girders is taken as 5,500 tons per square inch.

Since $M/I = 2f/D$ where f is the limiting fibre stress and D is the total depth of a symmetrical section we have

$$\delta = \frac{5}{48} \times \frac{L^2}{5{,}500} \times \frac{2f}{D} = \frac{1}{26400}\,\frac{f L^2}{D}.$$

Now in the case of a long strut, if the direct stress is ignored, practically the same law should hold, since

$$M = Pe \times \delta \quad \therefore Pe = M/\delta,$$

but

$$P e = \frac{\pi^2 E I}{L^2}$$

$$\therefore \frac{M}{\delta} = \frac{\pi^2 E I}{L^2}. \quad \therefore \delta = \frac{M L^2}{\pi^2 E I}$$

but

$$\frac{M}{I} = \frac{2f}{D}. \quad \therefore \delta = \frac{2 L^2 f}{\pi^2 E D} = \frac{2}{9.87 \times 5{,}500}\,\frac{L^2 f}{D}$$

$$\therefore \delta = \frac{1}{27100}\,\frac{f L^2}{D}.$$

The deflections calculated by the above means agree with the results of experiments. Therefore in designing beams to withstand combined stresses the approximate deflection should be calculated by the formula

$$\delta = \frac{1}{26400}\,\frac{f L^2}{D}.$$

In experimenting with metal construction one is impressed with the inconceivable number of designs which are possible. The most suitable design varies with each type of machine and the load which it is to carry. The duralumin designs previously shown are suitable for a large machine. In the case of machines of intermediate size, i.e., the order of 10,000 lbs. to 12,500 lbs., a suitable type of section is found to be one in which the main members are of channel section, which may be corrugated when necessary to reduce the effects of failure by secondary flexure. The actual section as designed is shown in Fig. 30. With thicker sections the central corrugations may be dispensed with. A spar of this type weighs only 75 per cent. of that of a corresponding spruce spar of the same strength.

A duralumin spar suitable for a small machine, such as the Avro, is shown in Fig. 31. This was taken after the wing had withstood a load factor of 10·7. Fig. 32 shows a front view of the whole structure taken after failure. Fig. 33 shows a side view of the complete wing structure taken immediately after failure. The excellent way in which this construction has withstood this phenomenal load is clearly shown in the engravings and requires no comment. The large initial deflection on the starboard side was due to the elongation of the brass thimbles fitted to the splicing of the wire bracing which is clearly shown in Fig. 31. This deflection ultimately caused the failure to occur on the starboard side.

In investigating the suitability of a construction to withstand the loads which are to be put upon it, care should be taken to reproduce as nearly as possible the conditions under which the specimen will be loaded in practice. Thus, the specimen should be subjected to the same bending moment and end load as in practice. Reference has heretofore been made to the serious errors which have been made in testing wooden specimens in pure bending instead of in combined bending and compression. The same errors may be made, if the correct procedure is not followed, in testing metal construction. In the first experimental stages of metal construction the author was unable to get certain manufacturers to construct specimens longer than 3 ft. Arrangements were therefore made to test these specimens in shackles, as shown in Fig. 34. The height of the shackle was varied to give the correct proportions of end load to central bending moment. Some results obtained with this apparatus on various types of spars are given in Table I of Appendix IV. As soon as circumstances would allow, and suitable designs had been selected from the large numbers tested, arrangements were made for the specimens to be made equal in length to the distance between the points of contraflexure in the actual spar. The specimens were then tested as shown in Fig. 35. The end load L, and the bending loads W, were applied in the correct ratio until failure occurred. The bending moment at the centre of the specimen, as is shown in Fig. 36, is the same as in the actual machine. Table II, Appendix IV, gives the results of testing Rudge and Avro spars by this method. Alternatively to the above the lateral loads W may be dispensed with providing the end loads L are given the correct amount of eccentricity to provide the necessary bending moment.

In presenting the subject of metal construction, the author has felt that the problem is too vast to be dealt with as a whole. He has, therefore, confined himself to a few basic principles and solutions to act as the basis of a discussion. He feels, however, that metal construction has a great future, and in placing before you a little of the work carried out in the last few strenuous weeks of the war, it is hoped that the subject will receive the attention that it deserves from our aeronautical engineers and designers. All the information now set forth has been obtained from private sources, but before leaving the technical department the author took action to place on record a much fuller account. This should now be available. He desires to record his indebted-

ness to General Weir and the authorities of the Air Ministry for permission to read this paper, and to tender his sincere thanks to his colleague, Major Wylie, R.A.F., who has been associated with the author in the develop-

Fig. 34.

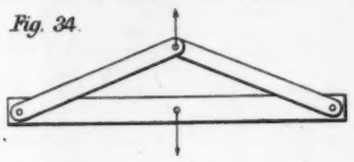


Fig. 35.

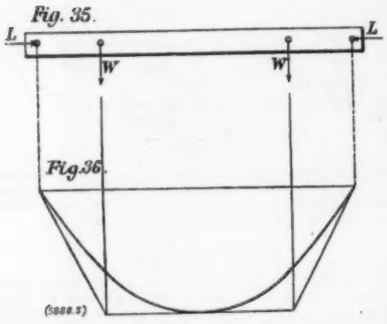


Fig. 36.

ment of metal construction throughout the country. He would also like to record his thanks to the various firms with whom he has been associated for their most courteous co-operation and for the ability and energy which they brought into requisition.

(To be continued.)

RECONSTRUCTION OF TRADE.

To the Editor of Engineering.

Sir,—When is this essentially vital problem to be tackled with energy and the further spread of unrest to be dealt with. What bars the way to secure what the Prime Minister has spoken so often about, an A. 1 country? Surely we have had sufficient talk, but when are we to do; what outline have we of even proposed harbouring of our resources?

Germany with a reduced service will require less to be spent on same, permitting the balance to be devoted to reorganise her industries; against this we have proposed even greater expenditure on our forces; in what way are we to expect our Air Force to act as our Imperial Defence, and if not as Imperial Defence, what commercial purpose is it to serve?

When are we to have control done away with—control of our industries—so that full scope is given to live firms who can produce and give healthy returns on their production, as against the war conditions of relegating work to areas—for example, steel plates, &c., confined to, as I understand, a freight charge of 5*s.* per ton?

We must get back to not merely pre-war conditions, but conditions that will foster home production, not by unreasonable tariffs, but by such tariffs that will be equitable all round. Some one may say that this is political; it is not; it is commercial, the best condition would be universal banishment of tariffs—Cobden's idea; but we know that Cobden's ideas or theories have never been acted upon, or if acted upon, have been abandoned by every other country almost but ourselves. We cannot exist by our supplies coming from America, Germany, or any other country. Nor is it to be expected that boroughs or city corporations can pay for steel rails, if our rolling mills are closed down.

If the war just ended has proved anything, it has proved this, that this country is neither devoid of brains, nor of virile man and womanhood. We had too many German and American agents in this country, Britishers at that, acting and using their influence in favour of foreign goods, and this must be curtailed, if not stamped out. Give the men of this country the same opportunities of proving their initiative and resourcefulness as they proved during the war. Then if they fail—which I am certain they will not—let those commercial traitors again take up their work, but not till then.

Our electrical trade, I know positively, was seriously handicapped by Germany. How? Because German firms, by State banking facilities, would take payments by instalments, whereas British firms required a clean trade settlement, as this applied to the electrical it also applied to other trades.

Establish a consultative body of employers and employees of, say, the coal, iron and steel and engineering trades, and as many other sections as is thought advisable, such as cotton, woollen, glass, chemical, dyes, &c., and have such a man as, for instance, Lord Askwith, who proved himself a man able to secure harmonious conditions in labour troubles, as president over same; let these men determine how this land of ours can become an A. 1 country, an A. 1 Empire. Give fuller interest in production to the workman, get rid of the "ca'canny" agitators, and we will have a country of brighter, more intelligent men, a country with better and happier houses. Then, indeed, will we feel surer that those brave men who made such sacrifices for liberty and justice, have not failed in their objective. Peers and costers, employer and employee, stood shoulder to shoulder in war; then why not in peace and construction. The matter only needs to be tackled in the right spirit, with the same spirit as was born five years ago. Then why this inertia, this stagnation?

I am, Sir, Yours faithfully,

David A. Sherry, A.M.I.Mech.E.

Heaton Grove, Newcastle-on-Tyne, August 5, 1919.

THE BUILDING OF AIRSHIPS.

To the Editor of Engineering.

Sir,—According to a recent statement in the House, the Government is now embarked on a programme involving the construction of six large rigid airship at a combined cost exceeding 2,000,000*l.*

Now, it is acknowledged that, excepting for coastal patrol work, the hydrogen-filled airship, on account of its vulnerability, is a failure as a war weapon. While on the other hand it is officially claimed that there is a great future for airships for commercial purposes, nothing that has been accomplished up to the present gives the remotest indication of the possible future justification of this claim.

A hydrogen-filled airship, as instanced among other cases by the recent tragic fate in the North Sea of N.S. 11, followed a few days later by the Chicago catastrophe, is vulnerable to other agencies, besides enemy action. In war time, questions of personal safety must frequently, to some extent, be subordinate to other considerations, but this does not apply to commercial flying. The possibility of disaster by fire must be entirely eliminated before airship flying can ever be really commercial. This can only be done by the use of some non-inflammable gas in place of hydrogen, and the only known gas which can be practically employed for this purpose is helium. Unfortunately there is only a very limited known supply of helium in the world, which is recoverable at anything like a reasonable figure—far less than will be necessary if commercial flying by airship is to be developed on a large scale.

Furthermore, an airship is so absolutely dependent on the weather conditions—much more so, in some respects, than a 'plane—that regularity of service, the basis of all commercial undertakings involving question of transport, cannot be relied on. An airship may be all right once it is in the air at a proper altitude, with plenty of petrol on board, but it can only start under favourable weather conditions. Even R. 34 was delayed by the weather during her recent trip to America, yet, without detracting in any way from Major Scott's magnificent performance, it should be realised that the most favourable weather conditions for crossing the Atlantic obtain just about this time of year. A flight during the winter months would have been impossible. Still, even under average seasonable conditions of weather, R. 34 was only just able on the outward journey to make the passage under her own power. Had she carried more than two passengers or any cargo, she would have been derelict for want of fuel.

It is obvious that an airship like R. 34 is absolutely useless for long distance commercial flying because of its want of "lift," *i.e.*, cargo-carrying capacity, quite apart from other considerations. It may, however, be assumed that it is possible to construct an airship having a lift of, say, 10 tons available for commercial purposes—in itself, a tremendous advance on R. 34—and that the cost of such a ship would be not less than about 300,000*l.* But the life of an airship is limited. After a certain time the envelope becomes rotten, due partly to oxidisation of the "dope" or proofing with which the fabric is treated in order to render it gastight and partly, it is believed, to the effect of the ultraviolet rays. This occurs whether the ship is in flight or not. The depreciation of the engines is also very heavy. Taking it altogether, it may reasonably be assumed that under present conditions the average useful life of an airship does not exceed about five years. With a life limited to five years, there would be an annual charge of 60,000*l.* to be written off.

In the case of the institution of a regular airship service between this country and, say, America, it will be necessary to construct suitable sheds at each end. "Mooring out" is never very satisfactory except under the most favourable weather conditions, and may generally be looked upon as an emergency measure. Each of these sheds, with its wind screens, gas plant and other accessories would certainly cost not less than about 150,000*l.*, and would accommodate two airships. Assuming twenty years to be the life of such sheds—the usual construction is corrugated iron on steel framework—there is to be written off per ship per year a sum of 7,500*l.* for depreciation of the sheds alone, without taking into consideration any question of repairs and general maintenance.

An airship of the size of R. 34 requires under average conditions some 400 trained hands to handle it in and out of its shed. On occasion, this number may have to be augmented. The wages of such a landing party at each end are a direct charge against the cost of the service. Assuming an average wage of 50*s.* weekly, this alone amounts to the sum of 52,000*l.* per ship per annum.

Bearing in mind the fact that airship flights between this country and America are only possible at certain times of the year, it is reasonable to assume, allowing 14 days for the round trip (including time for refitting) that an airship under most favourable conditions will not make more than, say, 10 such trips in any one year. During this period a total cargo of 200 tons will have been carried, *i.e.*, 10 tons going west and 10 tons on the return journey east, for each round trip, at an expenditure, even without making any allowance for the actual cost of flying nor for general maintenance, as shown in the annexed summary of practically 120,000*l.*

	Average per Ship per Annum. £
Depreciation of airship	60,000
Depreciation of sheds	7,500
Landing party wages	52,000
Total	119,500

This is equivalent to a minimum possible charge, without allowing anything for interest on the money invested, of not less than 600*l.* per ton of cargo carried. It would be interesting to know how the authorities can reconcile with these figures, which are extremely conservative, the official claim that airships are likely to have commercial value, and to what extent this official attitude has influenced the present construction programme.

Yours faithfully,

Cecil Lightfoot, A.M.I.C.E.

9*h*, Cornwall Mansions, Regent's Park, July 30, 1919.

NOTES FROM SOUTH YORKSHIRE.

Sheffield, Wednesday.

Iron and Steel.—Engineering concerns have a considerable amount of work waiting to be completed, but can make very little headway owing to the crippling effect of the Yorkshire coal strike. While the bulk of unfinished contracts are for home requirements, export demands are also being held up, and difficulties of high costs enhanced. The coal deadlock has already caused the loss of several thousands of tons in steel production, but the damage to Yorkshire industry is even more serious than meets the eye. When work is resumed at the pits a fortnight or so must elapse before deliveries to iron and steel-producing concerns become normal, thus, even in the event of an early settlement allowing a further period for competitors to press their advantage in the export markets. Those Sheffield firms whose storage facilities are restricted and who depended wholly on the Yorkshire supply, have closed indefinitely. A few concerns whose plant is electrically driven are carrying on as usual, but in the majority of instances, despite the relief afforded by emergency supplies from Nottinghamshire and Derbyshire, the big steel-producing departments have suspended operations. To-day, close on 20,000 people, most of them steel workers, are idle, and their number is increasing daily. So great is the pressure on the services of the local Labour Exchange authorities for payment of unemployment donations, that the Artillery Drill Hall, one of Sheffield's largest public buildings, has been engaged for the distribution of relief. Owing to the general unsettlement, prices are largely nominal; but pig-iron is 20*s.* a ton dearer, billets are up 30*s.* to 35*s.*, and finished iron has advanced 30*s.* Thus both American and Belgian material is well below the price asked for Sheffield steel, and there is little doubt that consumers will be compelled to fall back on the Belgian supply to supplement local deliveries, as they did before the war. Inquiries at the works show that the demand for tools made of common steel is heavy. Files are in exceptional demand, so much so that one of the largest engineering firms has just opened a special file-making department. The introduction of file-grinding machines has increased output. There is also a strong call for rolled strip, engineers' tools, and machetes, the last named chiefly for South America, Africa and West Indies. Makers of agricultural tools could employ more skilled labour. The improvement in the high-speed and special steel trades is slow.

South Yorkshire Coal Trade.—Business is practically strangled by the continued set-down at the pits. Apart from the stocks held by the Coal Controller, the only supplies available are those which the strikers themselves have worked from outcrop seams, and which are being bought at 30*s.* a ton. Gas and electricity plants are kept going with difficulty, neighbouring areas having very little to offer after meeting their own requirements. A small tonnage is coming into the district for manufacturing purposes, but it is inconsiderable compared with the normal rate of consumption. Nominal prices:—Best branch handpicked, 33*s.* to 34*s.*; Barnsley best silkstone, 33*s.* to 33*s.* 6*d.*; Derbyshire best brights, 31*s.* to 32*s.*; Derbyshire house coal, 28*s.* 6*d.* to 29*s.*; Derbyshire best large nuts, 28*s.* 6*d.* to 29*s.* 6*d.*; Derbyshire small nuts, 27*s.* 6*d.* to 28*s.* 6*d.*; Yorkshire hards, 28*s.* 6*d.* to 29*s.* 6*d.*; Derbyshire hards, 28*s.* 6*d.* to 29*s.* 6*d.*; best slacks, 24*s.* to 25*s.*; nutty, 23*s.* to 24*s.*; smalls, 19*s.* to 20*s.*

Errata.—In our article on the "Development of Turbine Machinery for H.M. Torpedo-Boat Destroyers" we stated, in the last paragraph of the second column of page 139, that the first application of reduction gearing for turbines for propulsive purposes in the Navy was the Acheron and Ariel, by Messrs. Thornycroft, with Parsons independent impulse and reaction type of turbine, one on each of the two shafts, and in the Archer and Attack by Messrs. Yarrow, with similar two-shaft arrangement for independent Brown-Curtis turbines using a rather higher degree of superheat than in the earlier vessels. We learn, however, that the first application of gearing for war vessels was really in the case of the Badger and Beaver, where the cruising turbines were geared. The next step was in the case of the Leonidas and Lucifer, engined by the Parsons Marine Steam Turbine Company, where all-geared turbines were adopted. Further, the Acheron, Ariel, Archer and Attack have direct-driven turbines on two shafts, one turbine on each shaft; they are not in any way geared.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Holidays have this week considerably interfered with business, the market having been closed until to-day. Home requirements continue heavy, but transactions are not heavy, the uncertainty of the general industrial situation inducing a cautious attitude, and inquiries on export account show rather marked falling-off. Acute scarcity of Cleveland foundry iron continues, the output having further shrunk as the result of unsatisfactory working of the furnaces due to the peace celebration stoppage, and producers cannot cover commitments of August which they had entered into. Values keep steady. For home consumption, No. 3 g.m.b. Cleveland pig-iron and No. 4 foundry stand at 160*s.*, No. 1 is 164*s.* and No. 4 forge 158*s.*, but some sales of good grey forge have occurred at 160*s.* Export rates are 5*s.* above these quotations.

Hematite Iron.—More hematite iron is available for sale owing to suspension of deliveries to South Yorkshire customers, who have had to close down works because of fuel shortage. Home business is on a fairly good scale, but demand from abroad is only moderate. Nos. 1, 2 and 3 East Coast brands are 200*s.* and No. 1 is 202*s.* 6*d.* for home use, and for shipment abroad mixed Nos. are 205*s.* and No. 1 is 207*s.* 6*d.*

Foreign Ore.—Quietness characterises foreign ore. Consumers are well placed, most of them having considerable stocks, and substantial deliveries coming steadily forward in fulfilment of running contracts, so that with values tending downward, it is not surprising to find them holding aloof. Lower freights are looked for. Little difficulty is experienced in chartering steamers Bilbao-Middlesbrough at 26*s.*, so that best rubio ore cannot be quoted above 54*s.* 6*d.* c.i.f. Tees.

Coke.—Coke keeps steady and firm with a good deal of business passing. Advanced rates are maintained. Average blast-furnace sort is selling at 48*s.* at the ovens, and quality low in phosphorus makes 49*s.* 6*d.* at the ovens.

Manufactured Iron and Steel.—Finished iron and steel manufacturers are very busily employed on home contracts, but prospects are by no means encouraging; and as regards export trade the outlook occasions grave concern in view of the very keen and increasing American competition. Home prices have been raised, but export rates are matter of individual negotiation. The following are among the principal market quotations to home customers:—Common iron bars, 22*l.*; marked bars, 24*l.* 10*s.*; steel ship, bridge and tank plates, 18*l.* 5*s.*; steel angles, 17*l.* 15*s.*; steel joists, 17*l.* 10*s.*; steel sheets, 20*l.* 5*s.* to 23*l.* 5*s.*; galvanised steel sheets, 24-gauge, 28*l.* 10*s.*; and heavy sections of steel rails, 16*l.* 10*s.*

Iron and Steel Shipments.—During the month of July 15,410 tons of pig-iron were shipped from the port of Middlesbrough, 13,475 tons going to foreign ports and 1,935 tons going coastwise, as compared with June clearances of 16,310 tons, of which 14,360 tons went abroad, and 1,950 tons coastwise. Manufactured iron shipped last month amounted to 1,028 tons, as against 2,172 tons in June, and July loadings of steel reached 20,133 tons as compared with 22,845 tons in the previous month. The principal receivers of pig-iron last month were: Belgium, 4,175 tons; France, 3,001 tons; Italy, 2,925 tons; and Japan, 2,054 tons. India was the largest customer for both manufactured iron and steel, taking 305 tons of the former, and 6,816 tons of the latter. Other principal receivers of steel were: New Zealand, 1,923 tons; Holland, 1,628 tons; and Natal, 1,496 tons.

DETERMINATION OF VANADIUM IN STEEL.—The quantitative determination of vanadium in alloy steels is particularly difficult because almost all such steels contain also chromium which would similarly be affected by the reagents used in the analysis. In the *Journal of Industrial and Engineering Chemistry*, of July last, G. L. Kelley, J. A. Wiley, R. T. Bohn and W. C. Wright describe a method of electrometric titration which is said to answer for all alloy steels and not to be disturbed by the presence of chromium and tungsten. The steel is dissolved in sulphuric acid, and nitric acid is added to the solution drop by drop; when all the nitrous vapours have been expelled by boiling, the solution is diluted with water and more nitric acid is added. The solution is finally titrated at 20 deg. C. with ferrous sulphate and potassium dichromate, the electrometric method being applied for determining the end-point of the reaction. In this method two electrodes are inserted into the solution, in circuit with a delicate galvanometer and a rheostat; the light spot of the galvanometer is watched, and the respective reagent is added drop by drop until the galvanometer indicates a decided change in the electrolytic potential of the liquid. It is frequently advisable to add an excess of the reagent and to titrate back, so as to make sure of the end-point. When working, two years ago (*ibid*, page 780, 1917), on this analytical problem, the same investigators had found that the nitric acid they used did not quite complete the oxidation of the vanadium; it seemed to stop at 97·7 per cent. of the vanadium present. By using a more concentrated nitric acid and a more sensitive galvanometer they now realise an oxidation to the extent of 99 per cent. and a better titration. The electrometric titration, of course, requires the setting-up of apparatus which are not quite simple; for routine analysis, however, this trouble well repays itself.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scotch Steel Trade.—With the holidays finished and the peace celebrations now a thing of the past, the various works are slowly getting into working trim, but small output is still the cry. There are plenty of orders on hand meantime, but the near future is a matter of some concern for steel makers. Not only are our usual export markets being lost to us, but owing to rising costs the prices now necessary for Scotch steel are so high that foreign steel—manufactured and semi-manufactured—is finding its way here. The local consumers say that if they are to compete in the world's trade they must have cheaper material, and they are now forced to consider the favourable prices being offered by the foreign agents. This state of affairs is going to be one of considerable moment to the trade, as, when the present demand is worked off, there may be some difficulty in keeping the local steel works running. With prices at least 10*s.* per ton dearer—ship plates at 18*l.* 15*s.* and boiler plates at 22*l.* 10*s.* per ton—the local shipbuilders and engineering firms require a corresponding advance in their prices apart from the increase due to the rise in fuel and wages. It was hoped and anticipated that we would have secured many of the contracts for the reconstruction of Europe, but at the high prices now required it is feared that our share in that great work may not be very large. The following are the current prices agreed upon by the associated makers:—Angles, 18*l.* 5*s.* per ton; ship plates, 18*l.* 15*s.* per ton; and boiler plates, 22*l.* 10*s.* per ton, all delivered in the home area. For export the quotations are:—Angles, 19*l.* 5*s.* per ton; ship plates, 21*l.* 10*s.* per ton; and boiler plates, 25*l.* per ton, all f.o.b. Glasgow. The latter prices, in order to meet foreign competition, may possibly be slightly steadied, when a favourable specification is offered. At the present time the export trade is not very heavy, and in some of the markets the American competition is very keen, so keen indeed that until a very considerable reduction can be offered in our present quotations these markets would seem closed to us.

Malleable Iron Trade.—No change falls to be reported in the condition of the malleable iron trade of the West of Scotland, and as orders on hand are being worked off there are few others coming along to take their places. The start after the holidays was lacking in enthusiasm, and the present outlook is not too encouraging. Prices are as last quoted, but buyers are holding back and purchasing only sparingly.

Scotch Pig-Iron Trade.—The Scotch pig-iron makers are well supplied with orders for the present, but it is the more immediate future which is giving some thought. The price of pig-iron never was higher, and consumers are not willing to buy any distance ahead at present levels, with the result that fresh business is being kept down to its lowest. The output is nevertheless being readily absorbed, and for present requirements a much larger tonnage is being asked for than is available for delivery. Export business is a negligible item at the moment, and not only is the American getting free scope in the foreign market, but he is even offering fairish quantities for delivery at our own ports. Foundry iron is quoted at 10*l.* 10*s.* per ton for No. 1 quality, and 10*l.* 5*s.* per ton for No. 3 quality, while the price for hematite iron is 10*l.* 10*s.* per ton delivered at the local steel works. The latter continues in good demand even at that figure, but it is recognised that before long there will be an easing off.

STEEL WHEELS FOR AUTOMOBILES.—Dealing with the question of steel wheels for motor cars, *The Iron Age*, New York, says "that if a suitable steel wheel were provided and adopted by the automobile trade, the annual tonnage at the present rate of automobile building would be 50,000 tons to 100,000 tons. The price per pound would scarcely be an object. If the design is to be provided, it must be furnished by the steel industry. The automobile engineers cannot be expected to work out such a problem, for it involves some new method of manipulating or forming the raw steel."

70,000-KW. TURBO GENERATOR.—The Interborough Rapid Transit Company, New York, says *Electrical Review*, Chicago, has recently placed in operation at its Seventy-fourth Street Power House, a turbine which is rated at a 60,000 kw. capacity continuously, and 70,000 kw. for 2 hours, it being, therefore, the most powerful prime mover in the world. It has three elements, one high-pressure and two low-pressure, and is the first triple cross-compound turbine to be placed in operation. It will assist in meeting the greatly increased demand for transportation in New York City, due to the opening up of a new subway system and the extension of the service of the existing subway, elevated and subway lines. The machine, though consisting of three separate elements, is started, synchronised and controlled as a single unit. All of the turbines are of the pure reaction type, without the usual impulse elements, a form of construction considered preferable in view of the great volumes of steam to be handled. The high-pressure turbine is of the single-flow type and is of cast steel. The low-pressure turbines are of the series-double-flow type; that is, the steam enters near the centre of the turbine and flows as a whole through a portion of the blading and then divides into two portions, each of which flows through a separate section into the condenser. Since the low-pressure turbines must take high-pressure steam in case the high-pressure turbine is shut down, the central portion of these turbines are made of cast steel also. All three rotors are equipped with Kingsbury thrust bearings.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Local Markets.—New business on the coal market was again confined within very narrow limits, owing to the continuance of the restriction on exports. The authorities are still taking huge supplies of coal to meet the requirements of inland consumers and to keep up stocks at the coaling depots abroad. There is an enormous quantity of tonnage in dock, much of which has been held up for a fortnight and more owing to the refusal of the authorities to sanction the release of coals. Again, many vessels and their cargoes have been requisitioned to carry supplies to inland ports. The introduction of a 7-hours' working day in the mines has also adversely affected outputs, and this has reduced the quantities available for shipment. In fact, it is only here and there that odd parcels are being released for shipment abroad, and lately many vessels have sailed in ballast. At the same time collieries are behind in deliveries and have very little coals for disposal on the market. In the circumstances new business is virtually at a standstill and mainly confined to the purchases of bunker qualities; and for the isolated parcels available very high figures are demanded and forthcoming. Admiralty large coals range round 70*s.*, and for good Cardiff small steams from 50*s.* to 55*s.* is obtainable. Coke is also very scarce and firm at 85*s.* for allied countries, and 95*s.* for other destinations. A good demand exists for fuel, and with makers unable to satisfy the requirements of consumers abroad prices are firm on the basis of 75*s.* for allied countries and 80*s.* for other destinations.

Newport.—Monmouthshire qualities are also very scarce, with prices firm for the small available parcels. Black Vein, Western Valley and Eastern Valley large range from 60*s.* to 65*s.*, and smalls are worth anything from 45*s.* to 55*s.* Prices in all cases depend on the individual circumstances of buyer and seller, and there is little hope of any relaxation in the pressure for supplies.

Freight Orders Rescinded.—The most important event of the week was the announcement of the Shipping Controller rescinding the limitation of freight orders in respect to foreign voyages. In the case of the British coasting trade the maximum freight schedules remain, and the necessity of obtaining licences for foreign voyages is extended to vessels of 250 tons gross register and upwards in order to ensure an adequate supply of tonnage in the United Kingdom coasting trade. Thus for foreign trades there is now a free freight market, and merchants and charterers will be free to negotiate rates under ordinary commercial conditions for the carriage of coal abroad. Shipping, however, is still under control, and the necessity for obtaining licences for voyages abroad remains. The export of coal is also under control, and no cargoes can be loaded without the sanction of the authorities. Thus vessels can still be directed by the Shipping Controller to certain trades, and in view of the abnormal position there is little doubt that the Controller will be obliged to exercise his rights in this connection. It is not anticipated that there will be any appreciable alteration in foreign rates in view of the acute shortage in the amount of coal available for shipment, for under the new scale of distribution exports are limited to about one-third of the quantity sent from this country in 1913. Thus the demand for cargo space is considerably reduced. However, even so, France and Italy, particularly Italy, are short of coal, and it is quite possible that where an exporter can arrange a cargo, higher freights than the maximum will be forthcoming. For the present, however, rates remain round schedule levels.

MOTOR TUG GROVE PLACE.—Messrs. James Pollock, Sons and Co., Limited, have recently completed at their Faversham shipbuilding yard the steel tug Grove Place, for service on the Thames; her principal dimensions are the following: Length, 55 ft.; breadth, 14 ft.; depth, 8 ft. She is fitted with a 160 brake horse-power two-cylinder Bolinder engine, of the latest "M" type, developing normal speed at 225 revolutions.

EXTENSION OF OSAKA WATER WORKS.—An extension scheme for the supply of water to Osaka (states the Acting British Vice-Consul at Osaka) provides for a population of over 3,000,000. In their present condition the Osaka water works have a maximum capacity of supply equivalent to the requirements of a population of 1,950,000, and it is anticipated that in 1922 the demand will reach this limit. The new scheme aims at a capacity of supply amounting to an average of 3·2 cub. ft. per day at 3,100,000 persons. This average figure includes the demands of Osaka's many factories and work shops. The estimated cost of the extension work is put at 9,700,000 yen (approximately 1,080,000*l.*). Operations are to be commenced in October and completed by March, 1923. Before the work can be taken in hand the approval of the Ministry of the Interior will have to be obtained, and the plans have already been submitted for consideration. Of the machinery, &c., required in this connection the following items may be of interest to British manufacturers: Three pumps for use at the intake, capable of raising 1,776 cub. ft. of water per minute to a height of 28 ft. The pumps are to be vertical, directly connected with motors. Twelve pumps for transmitting water from reservoirs, capable of raising 600 cub. ft. of water per minute to a height of 160 ft. The pumps are to be vertical pumps, turbine type, directly connected with motors. Three 1,500 kw. dynamos, directly connected with steam turbines. Four 1,000 kw. transformers for receiving 3,000 kw. current. Further particulars can be obtained on application to the Department of Overseas Trade.

REVOLVING DOUBLE-CANTILEVER TEMPERLEY TRANSPORTER; DAWSHOLM GAS WORKS, GLASGOW.

CONSTRUCTED BY SIR WILLIAM ARROL AND CO., LIMITED, ENGINEERS, GLASGOW.

(*For Description, see Page* 189.)

PORTABLE PNEUMATIC GRAIN ELEV

CONSTRUCTED BY THE EAST FERRY ROAD ENGINEERING

(For Descri... Page 19

Fig. 1.

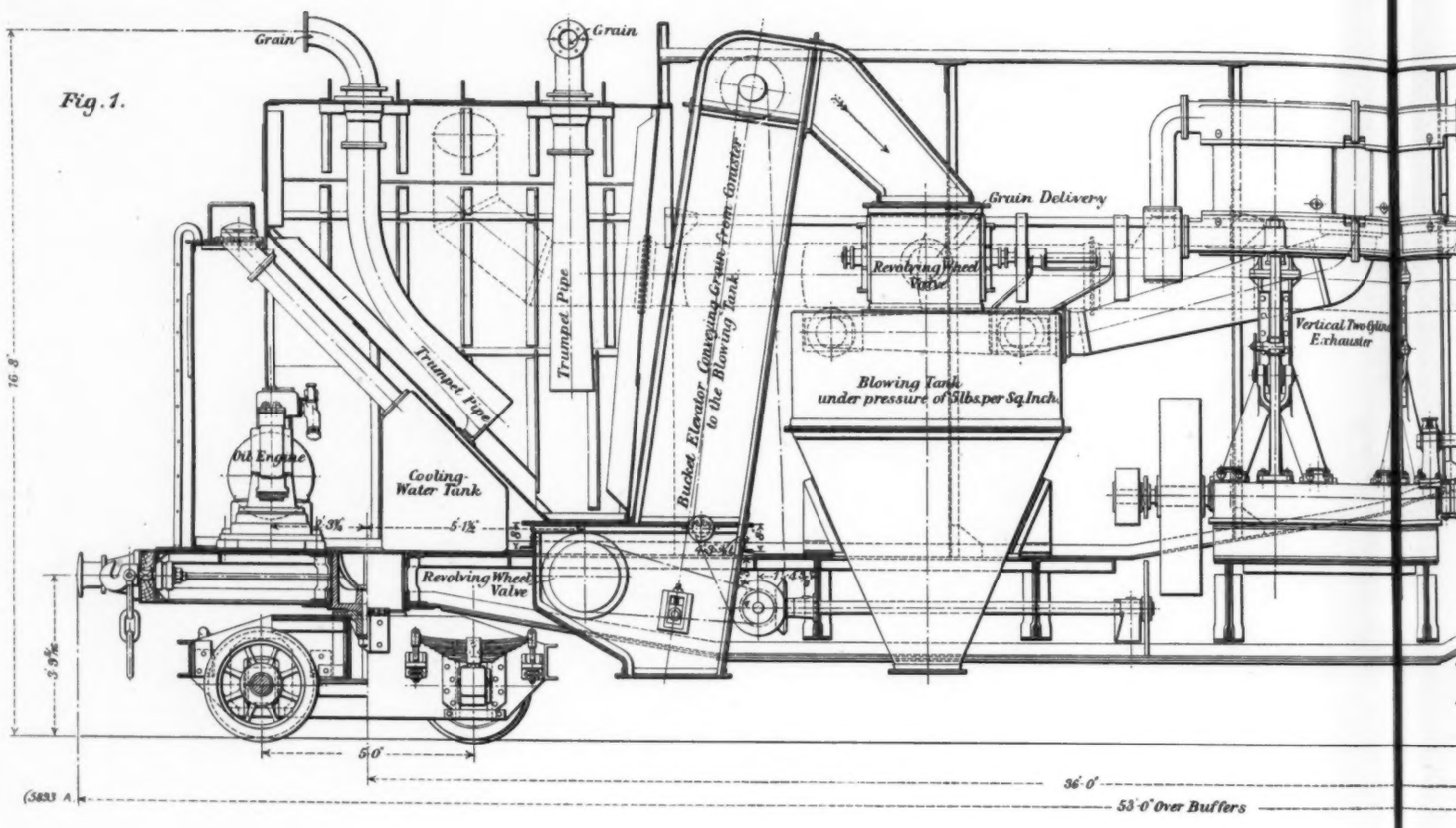
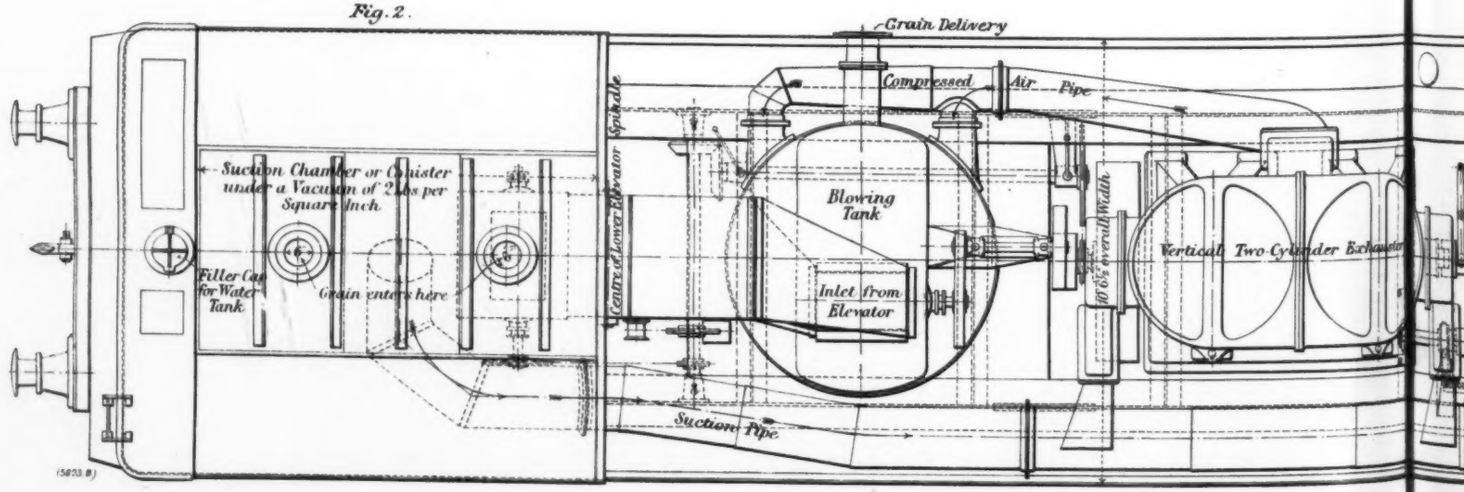


Fig. 2.



AIN ELEVATOR; DUCKHAM SYSTEM.

OAD ENGINEERING WORKS COMPANY, LIMITED, LONDON

(Description Page 191.)

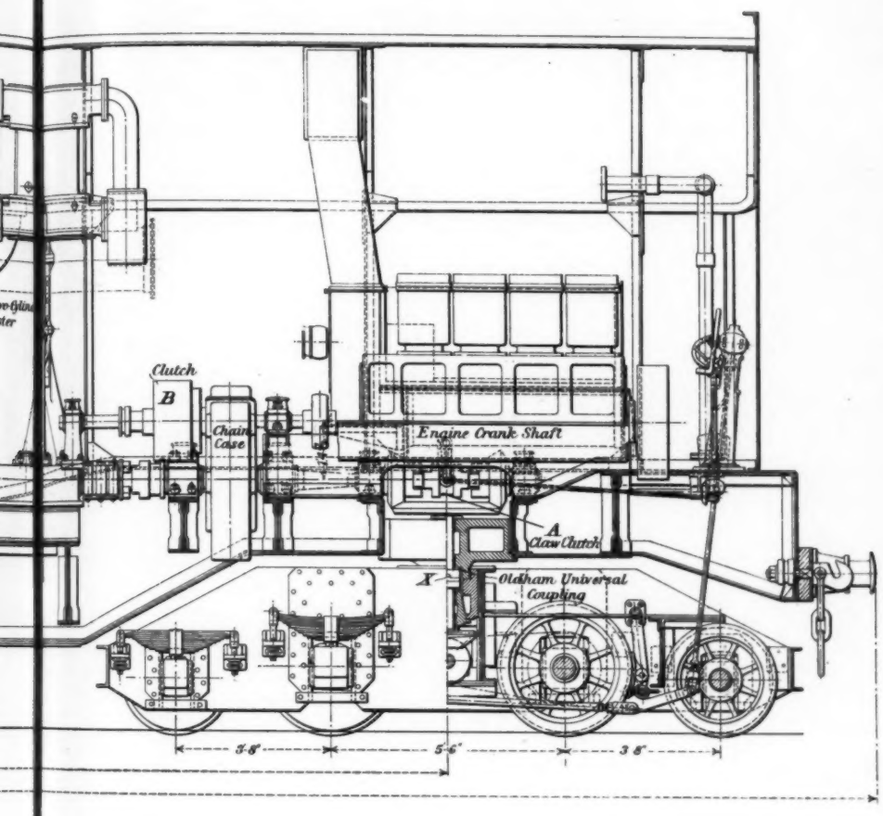
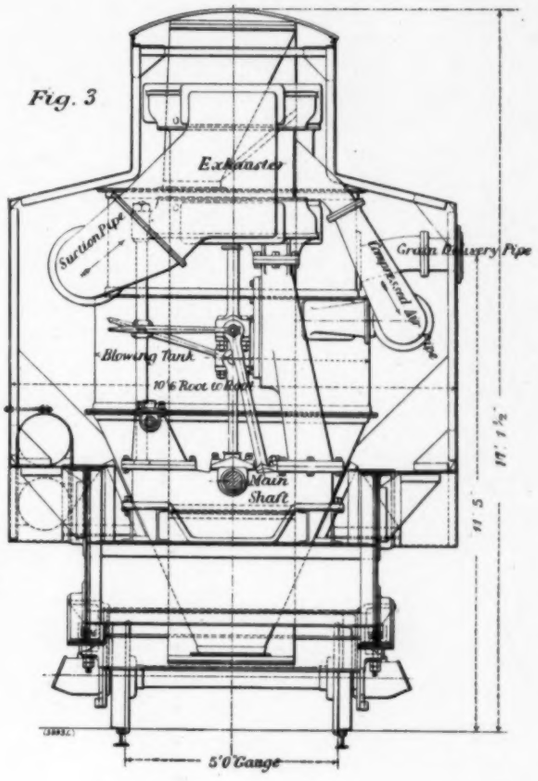


Fig. 3



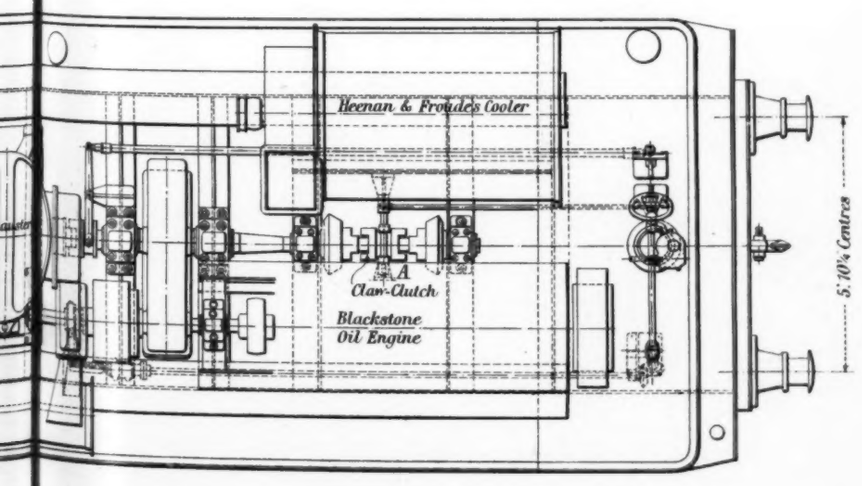
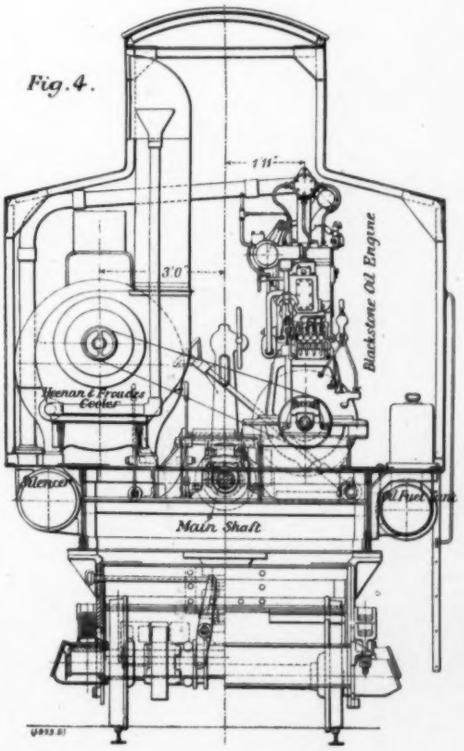


Fig. 4.



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ENGINEERING.

FRIDAY, AUGUST 8, 1919.

ANTI-DUMPING LEGISLATION.

QUITE apart from questions of labour troubles or higher prices, many branches of industry in this country are handicapped by the change from war to peace. Their factories and their organisation have for several years been devoted to specialised production for which there is now no demand, and the restarting of their old lines of work and the rehabilitation of their selling organisations must of necessity take some considerable time. This is a matter which very directly affects many lines of engineering work. In the early part of the year this subject attracted a considerable amount of public attention, but of late it is to be feared it has been overlaid by the more immediate interests of labour questions. The matter, however, is not one to ignore, or forget. Some protection is at present afforded by the import duties on motor cars, motor-car parts, gramophones, &c., but in general the manufacturer has so far been left to deal with the situation as best he may.

We do not, for the moment, propose to discuss the incidence of tariffs in the nurturing of a disordered industry. The Government has undertaken to make an announcement on trade policy before the recess and it will be well to wait for their proposals before dealing with the matter. There is, however, an independent method of affording protection to manufacturers in the initiation of anti-dumping legislation, and in view of the Government's commitment to consider this form of protection the subject is one of active interest. The publication a few days ago of a White Paper [Cmd. 265] giving a summary of this class of legislation as now in force in various parts of the Empire and in the United States, forms a sufficient text for a consideration of the matter at the present time.

In view of the present world shortage of most manufactured products it is probable that the prevention of dumping is not an immediate issue. Anything which can be made nowadays can probably be sold at a fair price, but our trade policy must have a longer vision than over the present, or into the immediate future. The world must settle down to a common round, sooner or later, and questions which now are in the background will come forward into a position of importance and urgency. The war has taught many lessons on the value of mass production, and it is not improbable that the fostering of mass production in the future may in some cases take the form of the export of surplus manufacture for sale at a lower price than is obtained in the home market. Such a procedure may well be financially sound, but from the point of view of the country to which such export is made the procedure is dumping, and dumping may adversely act on the industries of a country subject to it.

Dumping is naturally more likely seriously to affect a new or a struggling industry, and in view of the fact that all our industries are now struggling industries and that we have many new industries introduced by the war which we would wish to retain, the question of dumping, if not of immediate urgency, is still far from merely of academic interest. It is quite conceivable that dumping might arise in connection with, say, coal-tar dyes or magnetos, and though one may hope that these and similar industries which have grown up during the war may ultimately stand on a firm basis, it is doubtful if they could stand a serious dumping attack during the next few years. Dumping, of course, may arise merely from the disposal of surplus material, and it may frequently be a sound business policy deliberately to manufacture such surplus material with the idea of selling it at a lower price than is expected from the bulk of the product. It may pay even to manufacture the surplus for sale at a price which is below works cost, since by this means the total production may be kept up to the maximum capacity of a plant and total overall economy achieved. Dumping, however, may be undertaken as a deliberate policy, and at a loss, with the idea of so crippling an industry in a rival country that ultimately the command of the market may be achieved, and earlier losses more than made up. This class of dumping is not unknown in this imperfect world.

This latter aspect of dumping would appear to be that which has attracted most attention in the United States, and the anti-dumping legislation in that country is directed against it solely. In "An Act to increase the Revenue and for other purposes" which was approved in September, 1916, it is provided that any person importing articles into the United States for sale at a price substantially less than their price in their country of production, with the idea of destroying or injuring an industry in the United States or preventing the establishment of one, shall be liable to a fine of 5,000 dols. or imprisonment for a year. There appear to be no particulars available in respect to the operation of this Act, but in view of the fact that it was approved only in 1916 it is quite probable that no such case of dumping has yet arisen.

Legislative provisions for the prevention of dumping also exist in Canada, Australia and the Union of South Africa. In these cases there are no penal provisions. The Australian law is somewhat indefinite in intention. It is provided that the importation of goods may be prohibited or restricted if they enter into unfair competition with Australian industries, the preservation of which is advantageous to the Commonwealth. Canada and South Africa deal with the matter in the obvious and practical way of putting a special import tax on dumped goods. In both cases the tax is equal to the difference between the selling price of the article for export and "the fair market value" or "true current value" for home sale in the country of origin. In both cases the dumping duty is not to exceed 15 per cent. *ad valorem*. In the case of Canada there are various exceptions to the operation of the Act. Thus it does not apply to goods on which other duties amount to 50 per cent. *ad valorem*, or to sugar refined in the United Kingdom, or binder twine manufactured from New Zealand hemp, tampico fibre, sisal, &c.

The South African law dates from 1914 and the Canadian from 1907. No statistics are available bearing on the operation of the law in South Africa, but again it will be noted that it has only been in operation during the war period. In the case of Canada figures are available showing the financial results from the year ending March 31, 1909, to the year ending March 31, 1917. The average annual amount collected per annum in dumping duty over this period is round about 72,000 dols. The average annual total import duties over the same period was over 90,000,000 dols., so that the dumping duty represents less than 1 dol. in a thousand. It is not possible to trace any very definite trend in the figures, and the period with which they deal is comparatively short, but on the whole the ratio of amount collected from dumping duty to total amount collected on all duties probably shows a tendency to fall, suggesting that the dumping duty may be acting to check dumping. It must not be forgotten, however, that any effect of this sort may quite possibly be due to the economic effects of the war, which nearly covers the latter half of the period with which the figures deal.

In considering the relative merits of the two methods of dealing with dumping as illustrated respectively by the procedure of the United States and that of Canada, and the Union of South Africa, all the advantages appear to be with the Colonies. The American provisions are purely penal. Supposing dumping to arise in that country, it can be dealt with only by demonstrating that the importer of the dumped articles is acting with intent to destroy or injure an industry in the United States. This, we imagine, would be a very difficult matter to prove and apparently if it were not proved then, within the letter of the law, the dumping could not be interfered with. The United States Courts might find

a way out of this *impasse*, but the creation of such a position seems to be quite unnecessary. Dumping may affect the industry of a country quite apart from the objects of the dumper, and clearly the obvious and straightforward procedure is to neutralise it by the imposition of such a special duty as is current in Canada and South Africa. This covers all cases and acts quite independently of the intentions of the importer.

We have already said that conditions may arise in the future which will lead to dumping into this country, and we think the Government are well advised not to lose sight of the possible necessity for legislation dealing with it. If anything is done it would probably not be necessary to go further than the Canadian model for a satisfactory procedure. There is no reason why dumping, pure and simple, should not be dealt with. It has always been a hazardous task to attempt to read the future. It is doubly so now, but it will be admitted that it is at least conceivable that Germany may resort to dumping in an attempt to re-establish her industrial position, and in her efforts to recapture some of the lines of manufacture in which she was pre-eminent. Similarly dumping might arise from other directions in connection with the disposal of surplus resulting from mass production on a large scale. It is perhaps invidious to mention examples, but possibly we may be permitted to suggest that dumping might arise in the event of, say, a serious attempt to introduce the manufacture of typewriters on a large scale in this country.

We think we have made it quite clear in all we have written above that we are referring to dumping, and dumping only. The protection of industry by tariffs is altogether a different matter, with which we do not at present wish to deal. It is allowable, however, to point out that anti-dumping legislation will not protect the manufacturers and workpeople of this country from competition based on application and enterprise superior to their own. The manufacturing methods of the United States may very easily enable her to sell material in this country at a price which our manufacturers cannot approach, even though she may be keeping well within the provisions of any future dumping law. Similarly the low paid and industrious labour of Japan may enable her manufacturers to do the same thing. Much has been written on this subject of late, but not too much. The war is over, and our first and last business now is to re-establish a position something approaching that we held in earlier days of peace. The matter is one for the manufacturer, the politician, the workman, and the civil servant, but very particularly for the latter triumvirate.

MERCHANT SHIPPING AND THE WAR.

Lloyd's Register of Shipping, which now appears free from censorship for the first time since 1914 has a far higher degree of interest and importance than any previous issue in that it enables some reasonably accurate deductions to be made as to the effect of the war on the merchant fleets of the world. Not only have these suffered from the depredations of enemy submarines, but labour and materials, which in normal times would have been employed in merchant shipbuilding, have been diverted to naval construction, and other war industries, to an extent which can now be made apparent. The figures which we shall give below, amply justify the demands frequently made in these columns, and elsewhere, that as much as possible of the nation's industrial activities should be devoted to the construction of new merchant tonnage, and also make it possible for any thinking person to judge for himself as to the position in the world of commerce that this country will occupy in a very few years' time if these activities are seriously hampered by labour troubles.

Neglecting vessels of less than 100 gross tons, the steam tonnage of the whole world now totals 47,897,000 gross tons, some 2,500,000 tons more than the corresponding figure for June, 1914, but the steam tonnage owned in the United Kingdom has fallen from 18,892,000 tons in 1914 to 16,345,000 tons at the present time—a reduction of 2,547,000 tons, or 13·5 per cent. Thus instead of owning nearly 42 per cent. of the world's tonnage, as we did before the war, we now own only about 34 per cent. The United States, on the other hand, has increased her sea-going steamship tonnage from 2,027,000 tons just before the war to 9,773,000 tons at the present time, so that she now owns more than 20 per cent. of the world's total, instead of only about 4½ per cent. The only other country that has added materially to its merchant fleet during the course of the war is Japan, whose total tonnage of steamships now amounts to 2,325,000, which is 617,000 tons more than the figure for June, 1914; the increase in this case is thus just over 36 per cent. The tonnage of the British Dominions has increased from 1,632,000 to 1,863,000 during the war, an addition of 14·1 per cent., but the mercantile fleets of most other countries have either remained practically stationary or have diminished more or less. Next to this country, Greece has suffered the greatest loss in merchant tonnage, the Greek tonnage having fallen from 821,000 to 291,000 during the period under review. The loss is thus 530,000 tons, or 64·6 per cent. of the pre-war tonnage. Of the Scandinavian nations, Norway has sustained the greatest loss. Norwegian steamships now total 1,597,000 tons, as compared with 1,957,000 tons before the war, while the Danish tonnage has fallen from 770,000 to 631,000. Relatively the losses of these two countries are almost equal, the reduction in both cases being about 18 per cent. of the pre-war tonnage. The Swedish merchant fleet has been reduced by 98,000 tons (9·7 per cent.), the figures for 1914 and 1919 being 1,015,000 gross tons and 917,000 gross tons respectively. Italy and Spain have both suffered material losses of merchant ships during the war, the losses of the former country amounting to 192,000 tons and of the latter 175,000 tons. Italy's merchant fleet now amounts to 1,238,000 tons, and Spain's to 709,000, the percentage reductions being 13·4 and 19·8, respectively. France and Holland have both added slightly to their merchant ships, France by 40,000 tons (2·1 per cent.) and Holland by 102,000 tons (6·9 per cent.). French merchant steamers now total 1,962,000 gross tons, while those of Holland amount to 1,574,000 tons. With regard to enemy countries the figures given for Germany show that the German merchant fleet now totals 3,247,000 gross tons, a reduction of 1,888,000 tons, or 36·8 per cent. on the figure for 1914, while ex Austro-Hungarian ships now amount to 713,000 tons, as compared with 1,052,000 tons before the war; the loss in the case of the latter country thus amounts to 339,000 tons, or 32·2 per cent. These figures, however, require some explanation as actually they include all enemy vessels not captured or requisitioned at the time of the armistice. As a matter of fact some 1,750,000 tons of enemy vessels have been taken over by the Allies since that time, so that the enemy losses are considerably heavier than would appear from the figures given above.

Having thus considered the position of merchant shipping as it actually exists to-day, it may now be instructive to make some comparisons with the position as it might have been at the present time but for the occurrence of the war. Lloyd's Register has carefully estimated the increase in tonnage that would have taken place on the assumptions, firstly, that the percentage of addition to the world's tonnage would have continued at the ratio recorded during the last fifteen years before the war, and that the percentage of the United Kingdom tonnage to that of the whole world would decrease in approximately the same ratio as was recorded in the most recent of those years; secondly, that countries in which there had been a large addition of tonnage during the previous quinquennial period might be expected to show a reduction in the ratio of increase; and thirdly, that allowances should be made in the cases of countries the pre-war conditions of which pointed to the acquisition of tonnage, in the near future, at a higher ratio than had actually been recorded in the previous period. On these assumptions it is estimated that the world's steam merchant tonnage would now have amounted to 55,370,000 tons, which is nearly 7,500,000 tons more than that actually in existence at the present moment. This latter figure may then be taken to represent the total deficit in the world's shipping as a result of the war. On the same suppositions the total tonnage of the mercantile steamers of the United Kingdom would have been 21,348,000 tons instead of 16,345,000 tons—a difference of over 5,000,000 tons—and instead of owning only 34 per cent. of the world's tonnage, as stated above, we should have owned nearly 39 per cent.; even this, it should be noted, is a smaller proportion than was owned by this country before the war. The United States, on the other hand, has increased its sea-going tonnage by more than 7,000,000 tons above the tonnage it would probably have owned to-day had development continued on pre-war lines. Japan's position in the shipping world is now rather better than would have been expected if the war had not occurred, and the positions of all other countries have suffered more or less. Germany, for instance, would probably have had nearly 7,000,000 tons of steamships to-day, instead of about half that amount, and Norway would have owned rather over 1,000,000 tons more than her total tonnage amounts to at present. The losses of Italy and France may be taken as 677,000 tons, and 536,000 tons, respectively, while Holland, the only other country worth mentioning individually, would probably have owned about 384,000 tons more than her present actual tonnage.

These figures are, of course, of a somewhat speculative nature, and unforeseen circumstances, other than the war, might possibly have modified them considerably. It is, however, impossible to arrive at any reasonable conclusion as to the effect of the war by merely comparing the conditions to-day with those existing in 1914. Some allowance must be made for the developments that would have occurred in five normal years, and the assumptions made for this reason, as outlined above, are probably not far from the truth. In any case, the most important points, which are shown most clearly, are that while the United States and Japan have both improved their positions in the matter of shipping—the former country enormously so—the United Kingdom has fallen back. Our losses are, in fact, more than double those of all the rest of the world put together, and no opportunity should be lost of bringing these facts home to the public, particularly to those sections of it whose actions may help or hinder our efforts to retrieve our position.

ELECTROMETALLURGY IN GERMANY DURING THE WAR.

Definite information about the severe difficulties which the dearth of metals and other materials created in Germany almost from the beginning of the war is now becoming available, and it would appear from a contribution by V. Engelhardt to the *Elektrotechnische Zeitschrift*, of May 8 last, that electrometallurgy had a larger share in the fight against these difficulties than might be expected. As regards pig-iron, Scandinavia alone seems to have developed its electric furnaces during the war period; Germany did not start any electric blast furnaces. The production of steel and mild steel in electric furnaces, on the other hand, has considerably increased in all the war countries. In Germany the production of crucible steel (and electric steel) amounted in the years 1908, 1914, 1915, 1917 to: 88,183 (19,536) tons, 95,096 (89,336) tons, 100,578 (131,579) tons, 129,784 (219,700) tons, so that, comprising the steels made by these two processes under the term "high-class" steel, the proportion of electric steel was, in those years, represented by 18 per cent., 48·4 per cent., 56·7 per cent. and 62·8 per cent. of the high-class steel. For Austria-Hungary somewhat similar proportions are estimated, but the production of high-class steel was much smaller, altogether 79,057 tons in 1917, against 4,333 tons in 1908, and 59·7 per cent. of this total were electric furnace steel in 1917. This development of the electric steel industry, which has been equally striking in England and the United States is, of course, likely to continue. In Austria-Hungary induction furnaces predominate, in Germany arc furnaces.

The dearth of nickel, replaced to a small extent by molybdenum and tungsten, and also of chromium and vanadium, made itself very severely felt. The want of ferromanganese was less pressing at first, because the electric furnace does not require

much manganese as deoxidising agent. When manganese failed altogether and spiegeleisen grew very scarce, calcium carbide was resorted to, first in the solid state, then liquid, apparently with complete success. By paying particular attention to securing ash-free coke and other forms of carbon, the need of deoxidisers has further been reduced.

The dearth of copper has helped various other metals to the front; that it would also set up an, at least temporarily, important electrolytic-iron industry was hardly to be expected. Artillery trials having demonstrated that electrolytic iron could replace copper as material for the driving bands of shells without putting undue stress upon the guns, three large experimental plants for the manufacture of electrolytic iron were started at Leipzig in the Langbein-Pfanhauser works, in Berlin by Siemens and Halske A.G., and at Bitterfeld by the Griesheim-Elektron Company. The two companies last named then erected new plants, at München and Bitterfeld, for 200 tons of electrolytic iron per month; the Bitterfeld plant, however, was not in full working order by the end of the war. The process adopted is that of Langbein-Pfanhauser as further developed by Professor Fischer, now director of the Coal Research Institute at Mühlheim on the Ruhr; anodes of Martin-iron are electrolysed in ferrous chloride to which hygroscopic salts are added. Some new electrolytic iron processes, worked out by Siemens and Halske, Schlötter and Estelle were still in the experimental stage at the date of the report, and at present electrolytic iron remains too expensive on the whole.

With respect to copper itself the problem during the war was to obtain a pure copper from the miscellaneous alloys which the mobilisation of copper brought in. Several copper refineries were built in Germany and Austria, notably by the Siemens companies. The brass utilised comprised door brasses, candlesticks, picture frames, taps, weights, crucifixes, &c.; the brass was melted down, the zinc oxidised, and the crude copper cast into anodes and treated in the electrolytic refineries. The requisition of bronzes, largely church bells, followed that of brass. The disintegration of the heavy strong bell metal gave some trouble; the bells were inverted, filled with water and then shattered by exploding cartridges in the water. The bronze was then fused into anodes for electrolysis. Engelhardt does not give particulars, but mentions that the accumulation of stannic acid in the anode mud and in the electrolyte disturbed the electrolysis, and that some copper was first lost and recovered contaminated with lead and other impurities; those difficulties were, however, eventually overcome.

The recovery of tin was another difficult problem; Germany possessing hardly any tin ores, the stannic anode mud had to be reduced to tin, and special attention was further paid to the recovery of tin from bearing metal. Two works were built to work upold bushings, and it is said that they have been very successful, and that some works have also managed to economise tin by adopting electrolytic processes in their tin-plating shops. That zinc and aluminium have widely been used in the electrochemical industry has been mentioned in our columns on other occasions. There has been no important modification of the aluminium process. But the foreign supply of bauxite was stopped, and the best use had to be made of the bauxite stores of Carinthia, Hungary and Dalmatia and of superior clays in other parts of the Central States. Reliable particulars about the purification of clay have not yet been published.

MORATORIUM FOR PATENTS.

In our leading article on "The New Patents Bill," in our issue dated the 1st inst., page 149, we dealt with the Government Bill recently introduced to amend the present statute controlling the grant of Letters Patent for inventions from a general aspect, and dealt as far as possible with the amendments contained in the new Bill which seemed to be of greatest interest. Among them we set out the provisions relating to the extension of the life of such Letters Patent and suggested, as we have done before, that patentees should be given a chance to obtain a prolongation of their rights on the presentation of proof of the disabilities which they had suffered during the war. This matter is one which we regard as of some importance. It has been thought by some that the Government would introduce a separate Bill dealing with this, that is to say with a moratorium for patents which expired during the war, and also for patents still in force, the effective term of which would be reduced owing to the inability of their being worked during the past five years. Such indications as we can find rather point to the fact that there is no intention of bringing forward such a Bill. We are, therefore, of the opinion that it will not be out of place to consider this subject more fully, and we believe that there are certain suggestions contained in the remarks made below that are well worth such full consideration at this stage, seeing that amendments to the present Bill can and must inevitably be made before it becomes an "Act."

Letters Patent are granted for a term of fourteen years dating from the date at which the application was lodged. Therefore the ordinary period of about a year which is taken for the grant of a patent is counted as part of the patent term, and no action for infringement can be brought until the patent has been sealed, although redress can then be claimed back to the date at which the application was accepted. No renewal fees are payable for the first four years of a patent, but after that, fees amounting to several pounds on an increasing scale have to be paid year by year.

During the war many patents lapsed through failure to pay these renewal fees, say, because the inventor was abroad. No moratorium or further legislation is necessary to deal with that reason for a patent lapsing, because the Comptroller has power under certain temporary rules to enable the fees to be paid at any subsequent time while the rules are in force, provided it be shown to his satisfaction that the failure to pay them was due to the war. On the other hand, should a patent lapse by efflux of time during the war period, the Comptroller has no power to grant an extension of that period. The present Patents Act has a provision by which the normal life of a patent can be extended, but this is not suitable for the special circumstances of patents which lapse during the war because procedure is very costly, and the applicant has to prove in considerable detail that the invention is meritorious, and that the patentee has received no adequate remuneration. In a recently reported case of this kind (in the matter of Flemings Patent R.P.C. vol. xxxvi, page 55), a hearing for the petition of extension extended over 10 days in court, from which it will be assumed that the cost must have amounted to some hundreds of pounds and the work involved enormous. The merit of the invention and the result of the petition are not relevant to the present consideration, but it is clear that the procedure is not within the scope of the ordinary patentee.

It has been suggested that as practically everyone has been adversely affected by the war, there is no reason for preferential treatment to be given to inventors. There is much to be said for this, but on the other hand, there are several points of criticism which may be directed against it.

In the first place inventions are intended to be considered as quite distinct from other monopolies, for the Statute of Monopolies which declared all monopolies to be illegal, expressly excepted Letters Patent for inventions, but it was made a condition that such should be for the public good and should not operate to raise prices of commodities. If, therefore, the inventions in question do not fulfil these two requirements, then the grant would be illegal and with such there is no need to deal.

With regard to inventions in respect of which Letters Patent have been validly granted, these form to a large extent the basis of the country's trade, and their specifications constitute disclosures indicating lines of research and means of improvement. Such inventions, therefore, it would appear, should be encouraged in every way. It may be said that the best way of encouraging say, research, is to provide no means for restoring patents that have elapsed so that their property is public and those interested can seek to make improvements on them without restraint by the original patentee. Advantage need not accrue to the community in this case because it might merely mean that the original patent would be replaced by other patents. The value of many patents has been increased by the war. This applies not only to patents taken out during the war period especially for war appliances, but to patents in force before the war relating to ordinary commercial products which have been largely used during the war. Although it may be that increasing the term of such Letters Patent would give to the inventors advantages not possessed by other people, yet it is contended that not much harm would be done because by hypothesis the inventions were very useful. Others hold that the inventor was adequately rewarded.

On the whole, trade during the war has been so upset that to extend the life of all existing patents by a term of, say, five years, and to restore patents which lapsed during the war for a similar period, might be considered as giving to inventors all the benefits that they should require, the general public being protected by having a right to oppose an extension of the term in any particular case, provided the right was not exercised on frivolous grounds. Thus, if anyone had started to manufacture a machine of which the patent had lapsed this machine might constitute an infringement of an extended grant, but the person who constructed that machine should be entitled to use it without restraint.

NOTES.

Industrial Synthetic Ammonia.

In a communication presented to the Académie des Sciences, on May 19 last, Georges Claude, well known by his work on the liquefaction of gases and the isolation of the rare gases, submits some considerations as to the future of the synthetic ammonia industry, which has taken so extraordinary a development during the war. In peace time, he points out, the object of the fixation of atmospheric nitrogen is essentially the manufacture of fertilisers. In the shape of liquid, ammonia is useless as fertiliser and difficult to transport; the nitrate is valuable, but expensive; in the shape of sulphate, ammonia can be transported, but the sulphuric acid used for binding the ammonia is useless in the fertiliser, and thus a considerable fraction of the sulphuric acid manufactured is practically wasted. To reduce this cost, German chemists have, according to the reports of French chemical delegates, worked out a process of converting gypsum into ammonium sulphate. But we need not depend upon sulphate. According to Georges Ville, ammonium chloride is, as fertiliser, at least equal to the sulphate, and is less heavy and expensive in transport. Little would be gained, however, if the ammonia prepared were to be bound by hydrochloric acid instead of sulphuric acid. There is the ammonia-soda process successfully introduced by Solvay about 50 years ago after many failures. In this process large quantities of sodium chloride (brine) are decomposed with the aid of ammonia and carbon dioxide precipitating sodium bicarbonate; the carbon-dioxide is recovered by heating the bicarbonate, and the ammonia is recovered by boiling the ammonium chloride with lime. The recovery is fairly complete, but the resulting calcium chloride is a troublesome waste product, often a nuisance. If it were not for this well-known fact, the ammonia-soda process, which has largely superseded the Leblanc process, would be almost supreme. What Claude now proposes is to separate and to precipitate both the sodium bicarbonate and the ammonium chloride by the repeated-precipitation method of Schreib. He does not say how and where this process is carried out. But the advantage would be obvious. The ordinary Solvay process shares with the old sulphuric acid process the feature that expensive materials (ammonia and nitric acid respectively) are utilised for the purpose of preparing relatively cheap products (soda and sulphuric acid). If the ammonium can successfully be obtained as chloride, and if it should really answer as fertiliser, there would be a new important industrial application of synthetic ammonia, and the chlorine of sodium chloride and the lime would no longer be wasted as they are at present in many plants. Claude concludes that

every ton of fixed nitrogen would yield as by-product three tons of soda (sodium carbonate). That may be a legitimate form of expressing the problem. Yet one must remember that ammonium chloride has first to be tried as fertiliser. For one thing, the commercial sal ammoniac is apt to turn hygroscopic and acid; even the pure salt is difficult to pulverise and therefore not a convenient material for fertiliser-dressing.

Zirconia Furnace for Oxidising Atmospheres.

The new furnace of E. Podszus, specially designed for ceramic purposes and for working with a gas-oxygen blast at temperatures above 2,000 deg. C., is all built up of zirconia blocks and zirconia fragments, apart from its cylindrical iron casing. To obtain the most refractory zirconia this earth should first be fused; this Podszus effects by a method of his own which we noticed some time ago. Blocks up to 3 cm. in thickness are used in the new furnace, which is described in the *Zeitschrift für Angewandte Chemie*, of May 13 last, and they are backed and joined with the aid of a cement consisting of loose or powdered zirconia or zircon (the mineral) and about 1 per cent. of boric acid stirred into glycerin. The zirconia for the block should first be treated with hydrochloric acid to extract iron; some other impurities are gradually being volatilised afterwards during the working of the furnace. The bottom of the furnace is formed of zirconia gravel. Through this portion pass the two pipes which supply gas and air or oxygen to the four or eight burners inside the furnace. The fixing of these pipes and the construction of the furnace top—a straight cover—are mechanically the most difficult problems. The burner orifices or tuyeres are made of highly-baked zirconia, and the burners are so grouped that the flames are kept in circular motion. The burners may be made in electrically-heated carbon tubes, but this is an expensive process; more economically a gas-blast is used, and the furnace itself is in fact designed chiefly for the purpose of preparing zirconia blocks and tuyeres and other zirconia articles. The gas is preheated by coiling the pipes around the outer wall of the furnace. The roof was first formed of heavy zirconia bricks; but such covers are apt to cave in, and it is preferable to build the cover up of relatively thin zirconia bricks provided with rod extensions, by means of which the bricks are attached to the firebricks above them. Small-size furnace may be closed by one zirconia brick of 2·5 cm. thickness; for furnaces of 10 cm. diameter and more the cover is built up as stated. The furnace is started with a mixture of gas and air fed in under pressure; to obtain the highest temperatures of 2,500 deg. C. the air is subsequently replaced by oxygen. A good deal of oxygen is thus wanted, but the working is said to be cheaper than that of electric furnaces. Podszus mentions that he used one of these furnaces for two years without having had to make any repairs to speak of. This statement refers to the year 1914, however, while the article in question was dated February this year. Ordinary illuminating gas may be used.

LITERATURE.

Applied Optics; The Computation of Optical Systems, being the Handbuch der Angewandten Optik of Dr. Adolf Steinheil and Dr. Ernest Voit. Translated and edited by James Weir French. Two volumes, illustrated. London: Blackie and Son, Limited, 1918. [Price 12*s.* 6*d.* each volume.]

A determined effort to preserve the manufacture of optical instruments in the home markets, and to attack successfully the long-closed German monopoly, has led to the employment by many firms of larger scientific staffs, with consequent improvement in technique. One very desirable result of the introduction of this belated movement is the issue, by the scientific collaborators, of technical treatises having a closer connection with the commercial processes of manufacture than the purely educational works that have emanated from professional teachers. Such intelligent work, while it suggests the national importance of research and the advantages to be derived from co-operation among investigators, is calculated to hasten the recovery by this country of the leading position in optical technology that has been allowed to escape through indifference or selfishness. The stimulus derived from a great national awakening has not been allowed altogether to run to waste, and we may hope that the momentum acquired under the pressure of war conditions will be conserved, as a means for compensating the grievous losses which science has sustained on account of the war. The Advisory Council of the Department of Scientific and Industrial Research has sought to forward this end by encouraging the translation of German works, and a short time since attention was drawn in these columns to the publication of such a work by two members of the staff of Messrs. Barr and Stroud.* Mr. French is another member of the scientific staff of this eminent Glasgow firm, and his translation of the "Angewandten Optik," also published under the auspices of the same Advisory Council, will no doubt be welcomed by practical opticians. But while we notice with gratitude the care with which Mr. French has accomplished his task, the corrections which he has introduced and the illuminating nature of the notes he has added, there does not appear to us the same necessity to put this work in an English dress as in the former case. The recent works on refractometers by specialists displace much of the information supplied in one important section, and Mr. Dennis Taylor and other writers have done much to familiarise both workmen and students with the theory and practice of lens manufacture. The authors have considered almost exclusively the construction and possibilities of the achromatic doublet as arranged in the ordinary refracting telescope. The triplet form does not come under review, and the ingenious devices exhibited in combinations intended for photographic work receive no consideration. In a work on applied optics, we should have expected to have found the optical parts of the microscope discussed with some fullness, and we can only express our regret at the rather narrow view taken of a large and increasing industry. It is, however, only just to mention, that the German authors contemplated a work of three volumes, only one of which has appeared, dated 1890; probably if the treatise had been completed a wider outlook would have been presented, though even under these favourable circumstances the experience gained in the last thirty years could not have been incorporated.

The object of the editor is to supply a handbook presenting a complete trigonometrical system of optical computation in a form that exhibits both the convenience and the accuracy of the method. He regards it as demonstrated that the algebraical system of computation is so inferior in simplicity and rigour, that it should be superseded by the plan here developed. The special advantages of the trigonometrical method are not to be undervalued, and the insistence on a familiarity with this form of computation is justifiable. It is perfectly true that the path of a ray of definite wave-length can be traced step by step through a given optical system with mathematical accuracy, and the computation shows very definitely the possible limits of a so-called achromatic combination. The amount of the aberrations can be very conveniently expressed in either a linear or an angular form, and the origin of the imperfections clearly traced. It is equally true that the method has failed to recommend itself to practical opticians, who prefer to reduce arithmetical operations to the smallest possible amount, and to rely mainly on experiment for a satisfactory result. It is probable, too, that in the process of "figuring" as methods involving the use of interference fringes are substituted for the laborious examination of an artificial star, the employment of calculation will fall more and more into disuse. It may be that the curvature of the surface giving the most clearly-defined image will be found to depart more and more from that of the sphere.

The book is divided into two volumes, but the object of such division is not very clear more especially as the plan is attended with the distinct disadvantage that the explanation of the symbols employed and the sign of the conventions adopted, has to be repeated in the second part. This preliminary description is very elaborate and might well prove deterrent to the tyro, but once mastered the advantages are obvious, though some of the subsequent formulæ encumbered with asterisks and suffixes become confused and forbidding in appearance. Diagrams are added to illustrate the meaning of these symbols, and to give clearness to the plan of using the sign convention. By adopting red and blue colours to denote rays of different wave-lengths, such diagrams are well adapted to show the effect of dispersion—a very admirable feature. Besides these preliminary descriptions, the first volume contains three chapters. In the first of these the fundamental properties of a dioptric system are discussed, the ordinary formulæ are derived and the formation of images generally considered. The usual limitations are made of treating the light as monochromatic, keeping the incident cylindrical beam small, and limiting the inclination of the principal ray to the axes. Under such conditions, as is well known, it is possible to determine the path of a ray through a centred system of refracting surfaces and to exhibit the resultant effect with exactness. The method followed here is that due to Gauss, whether the position of the image point is found by calculation or graphically. In the determination of the cardinal points of a given system, the influence of Gauss is also noticeable.

The practical character of the work is advanced in the next chapter, for though the discussion is confined to a single lens, light is treated as composite and the defects of the image inherent in an actual lens system are narrowly examined. The path of two rays is completely traced, one paraxial and one near the edge of the disc, and as each white ray is dispersed at the first refracting surface, practically four rays are traced through the system. In the case of the paraxial ray, the object is to demonstrate the importance of the coincidence of the intersection in the axis of the selected coloured rays into which the ray has been separated. A distinction is drawn between the chromatic aberration, properly so-called, due to non-coincidence in the focal points, and the chromatic difference of magnification arising from want of agreement in the principal points. The path of the peripheral ray is, of course, needed to examine the amount of spherical aberration and the degree of freedom from distortion. Here, again, the spherical aberrations are limited to the consideration of the variation in the position of the focus, while the variation of the virtual emergence point positions is described as distortion.

The quantitative determination of these several aberrations is reserved to the last chapter. In this section, which forms more than half of the book, the paths of various rays, intersecting the axis at different angles, are calculated for a series of lenses, all having the same true focal length, but altered in thickness, in curvature, and in the type of glass used. A comparison of the results shows the effect that follows from the variation of each element independently, and is very helpful, since a guide is furnished that will determine the direction in which it is necessary to work in order to remove defects or to obtain a desired result. Some of the deductions may be sufficiently obvious, but the conclusions gain immensely in force owing to the quantitative examination.

Unfortunately it is sufficiently obvious that though the achromatic and spherical aberrations may be reduced to a minimum they cannot be entirely removed in a single lens system, and the achromatic doublet has been contrived in order to produce a satisfactory image. The theory of achromatism is the subject of the second volume. It is usual to say that a suitable combination of a crown and flint lens can always be found that will satisfy achromatic conditions. If this means that any two rays of the spectrum can be united at a definite focal length, it may be true, but a secondary spectrum will be left outstanding, the more troublesome the greater the separation of the selected wave-lengths. The removal of spherical aberration is not so simple or so complete. For the spherical aberration of a lens depends upon the equality of the division of the refraction over the two surfaces of the lens, reaching a minimum when the deviations at the two surfaces are equally great, and in the same sense. Further, as the minimum spherical aberra-

* "The Theory of Modern Optical Instruments," by Messrs. Emsley and Swaine.

tion for the positive lens, producing equal refraction at the two surfaces has a greater value than the minimum spherical aberration of the flint lens with equal refracting surfaces, it is possible to find a flint lens that will eliminate the spherical aberration of any crown lens, but on the other hand, corresponding with a flint lens having equally refracting surfaces, there cannot be found a corresponding crown lens having an equally small but opposite error. In combinations which have to be free from spherical aberration, the choice of flint lenses is limited to those which, in consequence of the unequal distribution of the refraction over the two surfaces, produce a spherical aberration as great or greater than that of the crown lens having equally refracting surfaces.

The determination of the optical character of the glass suitable for combination in an achromatic objective becomes therefore a matter of the first importance. The selection will depend mainly on the refractive index of the glass for the wave-lengths it is proposed to unite, in this treatise those corresponding to D and F. The authors describe in great detail the form and use of a suitable instrument designed for this purpose. Improvements, increasing both the convenience and the accuracy have been introduced since, but the principle remains unaltered. The instrument described in the text has a graduated circle of 6 in. diameter, divided to 10 minutes, and reading by two opposite verniers to 10 seconds. No angle can therefore be read off with a greater accuracy than 10 seconds, and yet the angles of deviation and their probable errors are worked out to hundredths of seconds. The refractive indexes are given to six places of decimals, and if the fourth significant integer is correct, the observer is fortunate. It is a small matter, but in another place several pages are occupied by discussing the proper number of figures to use in logarithmic calculation, and the useful rule is laid down for the guidance of others that "the number of significant figures employed should not be more than is actually necessary to give results of the desired accuracy."

A very valuable feature to which the preceding sections are merely preliminary is the exhibition of the entire process for determining the image formed in the focus of a doublet objective. The calculations are carried out to such an extent as to reduce the errors and aberrations to a minimum. The chosen dimensions of the object glass are as follows:—

	MM.
Semi-aperture	30·0
True focal length	720·0
Axial thickness of positive lens ...	8·0
Axial thickness of negative lens ...	5·0
Separation of the lenses	0·01

This is a very small objective, and the ratio of 1:12 seems excessive. How far it would be legitimate to substitute another unit as centimetres throughout, may be questioned. The writer of this review has heard eminent practical opticians assert that the rigorous deductions from trigonometrical formulæ are useless as guides to the construction of objectives of more than 6 in. aperture. But whether dissatisfaction with the final result is due to defective theory or to mechanical difficulties in producing accurate spherical surfaces of large area does not appear. In the special example worked out here, one is able to trace the amount of variation produced by small changes in a radius and the minuteness necessary for final accuracy is difficult of practical attainment. For example, the resulting chromatic arrangement depending on a presumed radius of 200·67 mm. had the value 0·037 mm., on reducing the radius to 200·3346 mm. the chromatic aberration is completely removed, but the reproduction of this degree of delicacy in actual work may not be possible. The computed spherical aberration on a first approximation amounted to 0·070 mm. This disaccord can be traced to the fact that the refraction is not proportional to the angle of incidence, but to the sine of that angle, and if the necessary correction be made, the spherical aberration is reduced to 0·006 mm. Even this small discrepancy may be made to disappear by an alteration of about 0·01 mm. in the radius, though such minute corrections have no practical value. The final errors in the image, expressed in millimetres, are as follows:—

Chromatic aberration	Nil.
Spherical aberration	Nil.
Chromatic difference of magnification	Nil.
Error depending on "sine condition"	+ 0·08
Gauss condition error	− 0·46
Chromatic difference of magnification for rim ray	− 0·40

The "sine condition" is fulfilled when the ratio of the sines of the angles of incidence and emergence is equal for both the rim and the axial rays and the "Gauss condition" when the axial and peripheral rays for the two selected wave-lengths intersect the axis in a common point.

The authors have, moreover, extended their investigations in a very useful form. By actual calculation they exhibit the values of the residual image errors given by a series of achromatic objectives, in which the forms of the lenses vary by progressive steps. In one group the preceding lens is the crown, in the other, the flint. Each of these groups is subdivided by distributing the refractions at the two surfaces of the back lens differently. There are, therefore, in all four classes or groups, and an inspection of the results deduced, enables one to select a form that is likely to give a satisfactory result and to trace the effect of varying the radii. In addition to these groups in which the refraction varies by regular steps of 2 deg., a series of special cases has been calculated to meet particular conditions. Throughout the refractive indices remain unaltered, but the two sets of tables and diagrams are also given, from one of which the radii of any cemented objective can be obtained by interpolation when the refractive indexes for the D and F rays lie within the limits ordinarily met with. From the other set, the radii of objectives can be found for which the spherical aberration is limited in both directions. In this latter set the lens thicknesses are taken into account. The final chapter gives details for the calculation of an image point, lying out of the axis, with a table of aberrations of the oblique image points for a series of objectives, completing a very thorough account of the theory of the achromatic doublet. Great practical experience has gone hand in hand with theoretical knowledge in the preparation of the volume, and Mr. French has rendered optical science no small service in directing attention to this collection of data. The editor does well, too, to remind us that the combination of art with science is necessary for the achievement of a successful result. The practical optician is an artist, whose work does not consist in the mechanical repetition of processes devised by others, but demands the exercise of originality and alertness of judgment.

Modern Management Applied to Construction. By Daniel J. Hauer. London: Hill Publishing Company. [Price 12*s.* 6*d.* net.]

A great deal has been written upon modern or scientific management, but the larger number of the books have been in connection with the movement as applied to engineering workshops. The author treats the subject from the point of view of the contractor responsible for carrying out contracts for large public works, such as railways, docks, drainage or similar civil engineering projects, and is apparently a strong advocate of modern ideas of management to which he must have devoted a lot of time and consideration.

The book is more or less a criticism of methods as they exist in the United States of America, and the author is ready with proposals for effecting improvement, and gives instances in which system has taken the place of muddling through.

The earlier chapters deal in some detail with the reasons for introducing scientific management on works of construction, and especially the importance of planning beforehand, the order in which the several stages of the work is to be carried out, the methods to be adopted, and the plant required to carry out the programme, instead of working, as is so often the case, on a day-to-day allotment of work which only leads, in most cases, to delays, loss of money and irritation. All this points to the necessity for efficient management for which the proprietors are only responsible.

In Chapter IV., the question of employing an expert conversant with improved methods, and the introduction of labour-saving devices is discussed, the author makes out a case for the development of efficiency engineering, but apparently he has had difficulties to contend with which also exist in this country, namely, the apathy of those holding responsible positions, and the views of the so-called business man.

In dealing with the fundamentals in choosing the type and amount of plant (Chapter V.), he points out that very often there is a want of judgment not only in the selection, but in the quantity of plant used on construction work, and that the knowledge in labour-saving devices is limited, due to the narrower outlook of the permanent staff, through being constantly on the same class of work for the same contractor for long periods.

In Chapter VI., the question of the application of motion and time studies is taken up in detail. "Motion studies" is the American name given to the study of movements taken by employees when carrying out a certain piece of work to assist him to work more easily and, therefore, with less fatigue, all with a view to securing a fair day's pay with a reasonable output. Somewhat similar investigations have been carried out in our engineering workshops for many years to assist the management in settling prices to be paid for a specific job or operation, or in connection with time allowances for work to be carried out under a bonus system. The author naturally takes up the study of motions as applied to bricklaying, shovelling, &c., and devotes considerable space to discussing the art of shovelling.

The sections on cost records and cost keeping are useful, the author emphasises the necessity for such records to be analysed, not only on the completion of the job, but frequently during the progress of the works. He mentions that cost-keeping is not book-keeping, but that it is supplementary to it. He is an advocate of keeping cost records in detail and on simplified forms. The difficulty is to obtain the day-to-day records of cost, whilst the work is in progress, belated cost records are of little use, because it is not possible to take any useful action after the job has been completed, but quite easy to call for reports and get into discussions, the result of which can only end one way. The accountants department should be made to understand that they exist to assist the company to make profits, and not only to compile figures for a balance-sheet.

In subsequent chapters systematizing construction and the effect of modern management upon workmen are discussed, but there is little which is new or striking here. The book should prove useful to those for whom it is written, and assist them in the introduction of new methods and economies which lead up to a satisfactory completion of the work to all concerned, namely, the customer, the contractor and the employee.

BOOKS RECEIVED.

The Principles Underlying Radio Communication. Radio Pamphlet No. 40. *Signal Corps, United States Army.* Washington: Government Printing Office. [Price 55 cents.]

Papers on the Design of Alternating Current Machinery. By C. C. Hawkins, M.A., M.I.E.E., S. P. Smith, D.Sc., Assoc.M.Inst.C.E., A.M.I.E.E., and S. Neville, B.Sc. London: Sir Isaac Pitman and Sons, Limited. [Price 18*s.* net.]

Studies in the Construction of Dams, Earthen and Masonry. By Professor E. R. Matthews. London: Charles Griffin and Co., Limited. [Price 4*s.* 6*d.* net.]

Zooms and Spins: An Army Pilot's Light and Shade Impressions. By "Rafbird." London and Edinburgh: Sampson Low, Marston and Co., Limited. [Price 3*s.* 6*d.* net.]

The Naval Annual, 1919. Edited by Earl Brassey, D.C.L., A.I.N.A., and John Leyland. London: William Clowes and Sons, Limited. [Price 21*s.* net.]

Petroleum. By Albert Lidgett. London: Sir Isaac Pitman and Sons, Limited. [Price 2*s.* 6*d.* net.]

Mining Engineers' Handbook. Written by a staff of Specialists under the editorship of Robert Peele. New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Limited. [Price 23*s.* net.]

The Safety of the Nation, Showing how our Security Rests upon our Industries. By Ian D. Colvin. London: John Murray. [Price 6*s.* net.]

Scientific Instrument, Glassware and Potash Production, B.O.T.—The Scientific Instrument, Glassware and Potash Production Branch of the Board of Trade has been transferred from 117, Piccadilly, to 7, Seamore Place, W. 1. Telegraphic address, Singlaspot, May, London; telephone number, Mayfair 5840.

INDUSTRIAL NOTES.

Mr. Herbert Smith, president of the Yorkshire Miners' Association, had an interview last Tuesday with Mr. Richardson, vice-chairman of the South Yorkshire Coal Owners' Association, when it was decided to hold a meeting last Wednesday, at Sheffield, of the South York Joint Board.

At the meeting in question it was resolved to send a joint letter to the Coal Controller informing him that points relating to the adjustment of piece-workers' rates and to working hours had been discussed in a friendly manner, and that it had been decided to ask him to meet representatives of owners and men for further explanation.

A meeting of both parties was also held on Wednesday in Leeds, to consider the winding enginemen's case in regard to hours and wages; no settlement was arrived at.

Last Monday a strike broke out on the London and South-Western Railway, and about 600 men, mostly members of the Associated Society of Locomotive Enginemen and Firemen left work in support of the Police Union. These men were followed by a number of drivers employed on the City and South London Electric Railway.

The number of policemen on strike throughout the country at the time of writing, due to the non-recognition of their union by Government, was 2,360.

Dealing with the railway dispute, Mr. J. H. Thomas, M.P., general secretary of the National Union of Railwaymen, stated last Tuesday that he was submitting the whole matter of the railwaymen's attitude in connection with the police dispute to the Executive Committee. The action of certain men in striking he added, was not only a grave mistake, but one for which the union was not, and could not in any way be, responsible. He had acquainted the men exactly with the position, and they had informed him quite frankly that they had acted on their own responsibility. The matter was one in which under no consideration ought the men to be influenced by local circumstances, passion or prejudice; they should go on with their work until they received the instructions of their Executive Committee.

At the close of the meeting of the latter committee, on Wednesday, the following official statement was issued :—

"The Executive Committee have discussed the situation in connection with the police dispute, and also the request of certain branches in different parts of the country to recommend an immediate stoppage in support of the police. They have decided that they cannot undertake any responsibility to summon a strike in this matter, and urge all their members now on strike to return to work immediately."

Grave unrest reigns throughout Liverpool owing also, presumably, to the non-recognition by Government of the Police Union and to the absolute refusal by Government to reinstate the policemen who have struck work. But the Liverpool unrest, together with the strikes which have broken out in other parts of the country, and in a number of trades and occupations, are attributed in some quarters to foreign action and support.

Sir Auckland Geddes in the commencement of the present week, made in Parliament the following statement concerning absenteeism among coal miners: "The figures for the years 1913 to 1918 are shown in Table I of the Appendices to the recently issued White Paper on the subject of the increase in the price of coal by 6s. per ton, which has been circulated to all hon. members. The figures are as follows: 1913 (six months, 10·7 per cent.; 1914, 10·3; 1915, 9·9; 1916, 9·7; 1917, 8·9; 1918, 11·0. The increased loss of attendance in 1918 was partly due to the influenza epidemic."

On Wednesday, July 30, by invitation of Sir Robert Hadfield, Bart., a number of members of the staff of Messrs. Hadfields, Limited, Sheffield, including representatives from the Board of Directors, offices, Research Departmental managers, foremen, workmen, apprentices and boys, journeyed to London in a special train in order to see the British Scientific Products Exhibition, Central Hall, Westminster; the Science Museum, Exhibition-road, South Kensington, and also Westminster Abbey.

The visit passed off admirably in every respect, and Sir Robert is to be warmly congratulated on his initiative; all those who took part, and not the least the younger members of the staff, will have been impressed on viewing the exhibition and museum with the value of inventions and discoveries in the furtherance of the British Empire's industries.

Sir Robert has supplemented his kind action by the offer of two prizes to the boys who will write the best accounts of what they noted during their visit.

The Federation of British Industries issued on July 30 a report on the Control of Industry, Nationalisation and Kindred Problems, from which we take the following :—

"Production cannot take place except through the previous accumulation of wealth by the efforts and savings of individuals. The capitalist system has provided the best machinery hitherto discovered for enabling and encouraging the individual to accumulate wealth and devote it to production. It has preserved the fluidity needed to ensure progress and to encourage the readaptation which is continually necessitated by changing conditions, new inventions and discoveries; it has provided unequalled means of encouraging those engaged in production to ascertain and fulfil the requirements of the individual consumer.

"The needs of a civilised population are so varied and its demands change so rapidly that a considerable risk is involved in all productive undertakings.

"The capitalist system has offered the maximum inducement to every citizen to take part in the great adventure of productive enterprise which has maintained the world and made civilisation possible. At the same time, the risk of personal loss involved has tended to restrain reckless and uneconomical production. These considerations apply with redoubled force to the export trade, in which the risks are greater and the requirements of the consumer more varied and more difficult to ascertain than in the home trade. The population of this country could not have existed, and cannot continue to exist, without a large export of manufactured goods to pay for the raw materials and foodstuffs which must be imported for its subsistence. The capitalist system has afforded ideal means for developing our export trade."

On the other hand, the report adds, "the State has, to some extent, engaged in manufacture for its own consumption; it has not, speaking generally, engaged in industries aiming primarily at the production of goods for exchange. This is the most difficult class of productive enterprise. The State is obviously unsuited for enterprise of this kind, and it is not surprising that, although State monopolies have been established in certain products for purposes of revenue, the results have in general been most unfortunate for the consumer. The same can be said of municipal enterprise. It is, further, inconceivable that an industry owned or managed by the State could enter into competitive trade in foreign countries in the present stage of human development, without encountering difficulties both economic and political which would be disastrous to any hope of amicable international relations . . ."

The report in question, of which the above is only a very brief abstract, will repay careful reading.

Speaking on July 31 at the statutory meeting of the Chemical and Metallurgical Corporation, Limited, Mr. Herbert Guedalla stated that when the corporation was formed Mr. Elmore transferred the benefit of an option he had secured with regard to the cementation process invented by Mr. François. The corporation knew as a practical fact that M. François had carried out numerous contracts successfully in shaftsinking through waterlogged strata. By the process, the water was practically sealed off.

According to *The Iron Age*, New York, for July 10, puddlers' tonnage rates again dropped at the last bi-monthly settlement, in Atlantic City, between the Amalgamated Association of Iron, Steel and Tin Workers and the Western Bar Iron Association. Sale sheets showed an average selling price of bar iron of 2·50 dols. per 100 lb. during the preceding 60 days, a reduction of 25 cents from the average price on May 1, when the last previous settlement was made. Under the scale of 1918–19, the price for puddling a long ton of 2,240 lb. of iron was 12·05 dols. on a 2·50-dols. card. The scale, however, has been advanced 5 per cent. as the outcome of a conference between the Amalgamated Association representatives and the Western Bar Iron Association. The new rate will apply during July and August. In May and June, puddlers received 13·30 dols. per ton; in March and April, 15·05 dols. on a 3·10-dols. card; and 16·80 dols. in January and February on a 3·45-dols. card.

Referring to the decision of the British Government to raise the price of coal to the consumer by 6s. per ton to meet the higher cost of wages and the reduction in working hours, the *Engineering and Mining Journal* of New York says: This is perhaps one of the most severe blows that labour has given itself for some time. It is surely a boomerang that will be felt most seriously by those employed in the manufacturing and export industries.

Great Britain has little water power. Her industries have been built up upon her coal mines, and unless every manufacturing and shipping nation experiences a like increase in the cost of fuel, England places a handicap upon her business that no adjustment at home can meet. But if every nation should do the same, it would be equivalent to marking up the price of every product that labour consumes, and labour would gain nothing but the illusory pleasure of having more money pass through its hands at a given time.

Some day, some time—it may be far away, but it will come—labour will learn that in normal times there is only one way of raising the standard of living, only one way of increasing the pleasures of life, and that is by harder work, more efficient labour—by increased production per unit of labour.

The same American journal says that England is not alone in her troubles with the coal miners and the production of coal. The Prime Minister of Australia, it adds, has taken over the output of that Commonwealth. It is the intention of the Government to fix wages and the conditions of labour, as well as the price of coal. If this results in lowering production and increasing the price of fuel, as has been the case in England, the Government will find that it has "fixed" some industries depending upon cheap fuel to an extent that will enable them to do without fuel or labour. It is to be hoped that the Prime Minister and the miners will both see the light before it is too late.

Mr. Harry Dubery, Labour Adviser to the National Alliance of Employers and Employed, has just returned from an extended visit to the British Army on the Rhine, where he has been delivering a series of lectures to the troops on behalf of the Education Department of the War Office.

Describing the general attitude of the troops, Mr. Dubery says :—

"One found considerably less dissatisfaction among the Army of the Rhine than existed in the Army in France and Belgium last November and December. A great many of those who wanted to be demobilised at that time, have, of course, gone.

"There is still, however, a keen desire for demobilisation among the bulk of the remainder, but it is substantially modified by the reports of how things are in England, the rank and file feeling that even though they object to the Army, and are anxious to be demobilised, they may perhaps drop temporarily into worse conditions because of the industrial unrest at home.

"The men as a whole, while not sympathetic with the labour unrest at home, are certainly not antagonistic thereto, being mainly consumed with a desire to share in the proceeds of the agitation should it be successful. The officers, however, as a class are much more concerned, and bitterly resent a condition of affairs which, they say, makes their re-employment in civil life at a reasonable salary exceedingly difficult, because most of them wish to enter that professional middle class which has been so hardly hit by the rise in the cost of living—which they hold is at least partly due to the high working class wages—and the income-tax, while, as a class, it has received less in increases than any other section of the community.

"They presume also that the signs of activity of a re-awakening of industry in Germany, will mean presently that the contracts in neutral countries will be lost to Great Britain, and that we shall steadily approach a parlous condition at home in which they will be involved.

"In spite of this, however, most of them are anxious for demobilisation, and are prepared to take the risks. They reason, many of them, that the Army in peace time keeps them fairly busy all day long on comparatively unimportant matters, and prevents them getting down for several hours at a stretch to educational schemes which would improve their chances in the professional labour market."

The British Industries Fair, 1920.—The Municipality of Birmingham and the Chamber of Commerce of that city who, under the auspices and with the support of the Board of Trade, are organising that city's section, are most anxious that it should be widely stated that the British Industries Fair (Birmingham) is actually a part of the exhibition to be held at the same time (February 23 to March 5, 1920) in London and Glasgow, and that the Birmingham schedule includes: Small machine tools, ropes and cables of steel and hemp, machinery belting of leather, rubber, &c., engineering requisites generally, engineers' tools, brass, copper, iron and steel tubes, pipes and fittings, heating appliances and furnaces. Only goods of British manufacture are allowed, and no productions which come within the description named above can be shown anywhere except in Birmingham. Although the city is allotting all its available public buildings to the fair, the council are very anxious to receive applications for space at the earliest possible moment, and those of our readers who are qualified to exhibit are strongly recommended to get in touch with the General Manager, Chamber of Commerce Buildings, Birmingham, at once. The fair, in its three branches, will constitute a comprehensive market for British goods; it will be visited by all the world's largest buyers, every visitor being present by invitation of the Board of Trade.

THE LATE MR. SAMUEL THOMAS WELLMAN.

We much regret to have to record the death, which occurred at Stratton, Maine, on July 11, of Mr. Samuel Thomas Wellman, one of the founders of the Wellman-Seaver-Morgan Company, of Cleveland, Ohio, and one of the directors of Wellman, Seaver and Head, Limited, London.

Mr. Wellman was born on February 5, 1847, at Wareham, Mass., and was the son of Mr. S. K. Wellman, superintendent of the Nashua Iron Company, Nashua, N.H. He received his early education at Nashua and, later, he attended Norwich University. In 1864–65 he served in the Civil War as a corporal in the First New Hampshire Heavy Artillery. Early in life he had displayed interest in the works at Nashua and became familiar with the various metallurgical operations therein carried out. In the 'sixties the works in question decided to put down a Siemens regenerative gas furnace for heating blooms; young Wellman was handed the drawings of the new furnace and built it complete. He went to Pittsburgh in 1867 and there assisted in starting a crucible steel melting furnace at the works of Messrs. Anderson, Cook and Co. This furnace melted a ton of steel, using on an average 1,000 lb. of cheap nut coal, a great improvement upon the former coke furnaces which took 3 tons of best coke at about treble the price of the nut coal.

Later, Mr. Wellman spent some time in the office of the Siemens agents in Boston, then at various steel works in different parts of the United States, starting crucible steel furnaces. He afterwards built open-hearth furnaces, including one for the Nashua works, combined with a plate and bar mill. He went to Cleveland in 1873, and there designed and built the Otis Steel Works, with which he was connected as engineer and superintendent for sixteen years. When in Cleveland, he worked out the two inventions with which his name is intimately connected, and which have since become absolutely indispensable to the economic operation of any open-hearth steel works, namely, the open-hearth furnace charging machine and the electromagnet for handling pig-iron and steel scrap. In 1890, he organised the Wellman-Seaver Engineering Company; this company, later, was consolidated with the Webster, Camp and Lane Company, Akron, and became the Wellman-Seaver-Morgan Company, with which Mr. Wellman was associated until his retirement from business, in 1900.

Mr. Wellman was president of the Cleveland Engineering Society in 1902-1903; president of the American Society of Mechanical Engineers in 1900–1901. He was also a member of the American Iron and Steel Institute; and since 1878, member of our Iron and Steel Institute.

Thornycroft War Vessels in the Thames Pageant.—There took part in the Thames pageant last Monday, two Thornycroft coastal motor boats, 40 ft. in length, having a speed of over 40 knots. These vessels carry 18-in. torpedoes, and proved the value of speed in naval engagements by successfully torpedoing German war vessels on many occasions, with but few casualties to boats or crew. The full story of the service has still to be issued, and should give a wonderful record of technical ingenuity on the part of the designers and builders, combined with reckless daring and devotion to duty on the part of those handling the craft. Another example was a duplicate of the famous little motor gunboats, also designed and built by Messrs. Thornycroft, which carried out the destruction of the German gunboat flotilla on Lake Tanganyika, Central Africa, thus most materially assisting in the East African campaign by cutting off means of communication in the rear. Similar Thornycroft boats have rendered valuable services in the Dead Sea and in North Russia.

The Institute of Metals.—The autumn meeting of the Institute (the first gathering to be held out of London, since 1913, when the meeting was in Ghent) will be held in Sheffield, on Wednesday and Thursday, September 24 and 25. The following is a list of the communications that are expected to be submitted: (1) Professor P. G. H. Boswell, O.B.E. (Liverpool), on "Moulding Sands for Non-Ferrous Foundry Work"; (2) Professor C. H. Desch, D.Sc., Ph.D. (Glasgow), second Beilby report on "The Solidification of Metals from the Liquid State"; (3) Miss H. E. Fry (Teddington) and Dr. W. Rosenhain, F.R.S., vice-president (Teddington) on "Observations on a Typical Bearing Metal"; (4) Dr. W. H. Hatfield and Captain G. L. Thirkell, B.Sc. (Sheffield), on "Season Cracking of Brass"; (5) Mr. R. E. Leader, B.A. (Sheffield), on "The Early History of Electro-Silver Plating"; (6) Mr. E. A. Smith and Mr. H. Turner (Sheffield) on "The Properties of Standard or Sterling Silver, with Notes on its Manufacture"; (7) Dr. J. E. Stead, F.R.S. (Middlesbrough), on "The Ternary Alloys of Tin—Antimony—Arsenic"; (8) Dr. F. C. Thompson, B.Sc. (Sheffield), Note on "Graphite and Oxide Inclusions in Nickel Silver."; (9) Dr. F. C. Thompson, B.Sc., and Mr. F. Orme, M.Met. (Sheffield), on "Some Notes on the Constitution and Metallurgy of Britannia Metal." Visits to works and excursions have been arranged. Further details can be obtained from Mr. G. Shaw Scott, Secretary.

REVOLVING TEMPERLEY TRANSPORTER.

We reproduce on page 182 a photograph of a rather uncommon type of Temperley transporter which has been designed and constructed by Sir William Arrol and Co., Limited, of Parkhead, Glasgow, and erected by them at the Dawsholm Gas Works of the Glasgow Corporation. It is used for conveying coke from the quenching pit to the storage area, and also for loading it into railway trucks and road vehicles. As will be seen from our illustration the transporter is of the revolving double-cantilever type, the cantilevers being carried by a steel-framed tower and the whole appliance being mounted on a circular brickwork pier. This arrangement enables a clear lift of 50 ft. to be obtained and, the high lift, of course, considerably augments the storage capacity of a given area. The length of the cantilevers is such that the load can be handled at any point up to a maximum distance of 100 ft. from the centre, so that, except for the small portion occupied by the brick pier, the whole area of a circle 200 ft. in diameter can be covered. As shown the transporter is fitted with a Temperley patent grab bucket capable of holding about 1 ton of coke, but an automatic dumping skip, holding 2 tons, is used when taking coke from the quenching pit, and, with this, the transporter can handle about 50 tons per hour.

As will be seen, the cantilevers are steel-framed structures of triangular cross-section, and these support the track or beam for the travelling carriage. The track is made up of steel sections strongly braced and stiffened at short intervals by means of steel brackets, and on this track runs the travelling carriage, which is mounted on four flanged wheels of cast steel. Two sheaves are mounted between the sides of the carriage for the grab-hoisting ropes and chain to pass over, and these sheaves are of large diameter and bushed with gun-metal. All other sheaves are similar in these respects, and in all cases careful provision for lubrication has been made. The movement of the traveller along the beam is effected by a high-speed single drum winch driven by a 25-h.p. motor, which gives a travelling speed of 600 ft. per minute. Two transporting ropes are coiled in opposite directions on the drum, led round sheaves at each end of the cantilevers, then round travelling compensators, and finally anchored to the ends of the carriage. The compensators, both of which can be seen attached to the beam in our illustration, enable the transporting to be effected while the hoisting winch is stationary, the travelling and hoisting motions thus being quite independent. The winch is fitted with an electric brake which is applied automatically when the current is cut off, and also comes into operation if there should be any failure in the power supply. The operations of lifting and lowering the grab, and also of opening and closing it, are effected by a double drum winch driven by a 50-h.p. motor, and the lifting speed attained is 190 ft. per minute with full load. The two drums of the winch are driven through epicyclic gearing mounted on an intermediate shaft, and the opening and closing rope for the grab is taken from one drum and the hoisting rope from the other. The ropes are led to the centre of the beam to a compensating device, and then back over the sheaves in the travelling carriage to the grab. The opening and closing of the grab is controlled by a hand lever and pedal, and the hoisting winch is provided with an automatic brake similar to that previously mentioned in connection with the travelling mechanism. Part of the weight of the grab is counterbalanced.

The grab is of the two-rope type with plain edges, and, as stated above, its capacity is 1 ton. It is opened and closed by means of a chain, which is arranged so that it can be easily disconnected when it is desired to remove the grab and replace it by the skip. The hoisting rope passes round two sheaves in the upper head of the grab, and is carried up and anchored to the frame of the travelling carriage, thus giving a double lifting purchase; this arrangement also prevents the grab from twisting and getting out of line. Three automatic dumping and self-righting rectangular skips are provided in addition to the grab, and these have a capacity of 140 cub. ft. each. They are controlled entirely by the transporter driver, who requires no assistance for dumping the loads.

The central tower is built up of rolled steel sections and plates, braced, gusseted and riveted together, and connected to the cantilevers by large gusset plates and bracing. The bracing is, of course, arranged to permit the free passage of the load from one side of the transporter to the other. The tower is mounted on steel carriages, each having two cast steel wheels which are bushed with gun-metal and mounted on fixed steel axles. The wheels run on a roller path fixed to the top of the pier and composed of a complete ring of steel sections with heavy steel billet on top machined to form a bearing face for the wheels. Cross bracings are fitted inside the roller path to carry a socket for the centre pin, which is of forged steel and is bored out to form a passage for the electric cables. The centre pin works in a bearing carried by the tower, and thus forms a pivot about which the whole transporter revolves. The slewing motion is imparted to the structure by a pinion mounted on the lower end of a vertical shaft, running in bearings attached to the tower, the pinion gearing with a pin rack formed on the outside of the roller path. The upper end of the vertical shaft is driven by a 12-h.p. motor through worm and spur reduction gearing, which is arranged so that the transporter makes a complete revolution in 2 minutes. This motion is also controlled by an automatic electric brake.

The driver's cabin, which can be seen on the left of the tower in our illustration, consists of a steel frame covered with plain steel sheeting, and provided with large windows which give the driver a clear view of the load. The cabin contains the motor controllers, operating levers, and switchboard, and is also provided with an indicator to show the position of the load at all times. The machinery is enclosed in another steel-framed house which is situated inside the central tower structure. Ladders and platforms are provided to give access to these houses, and to all other parts of the transporter requiring lubrication, or other attention. The motors are of the totally-enclosed series, reversing type, specially designed for transporter work and capable of being started and stopped at short intervals; they are wound for 500 volts continuous current. Each is operated by a drum-type reversing controller, and limit switches are provided to prevent overwinding and over-transporting. Cargo lamps, two of which can be distinguished in our illustration near the ends of the cantilevers, have been provided in approved positions, and generally it may be said that nothing needed to make the working of the appliance safe and reliable under all conditions has been omitted. The materials and workmanship used for both the structural and electrical parts were of first-class quality and the transporter has now been working satisfactorily for about two years.

Density and Refractive Power of Pure Glycerin.—H. Wolff (*Zeitschrift Angewandte Chemie*, 32, page 143) has redetermined the specific gravity and refractive power of solutions of pure glycerin in water. A solution of 76·77 per cent. gave at 13·8 deg., 22 deg. and 15 deg. C. densities of 1·2043, 1·1998 and 1·2036, the coefficient of expansion being 0·0004603. These results agree with Gerlach. The refractive index of an 86 per cent. solution was 1·4545, 1·4537, 1·4533 at 12·5 deg., 15 deg. and 17·5 deg. C.; for the 76·72 per cent. solution the corresponding figures were: 1·4401, 1·4395 and 1·4388. Thus the change of the refractive index per degree Centigrade was $2·8 \times 10^{-4}$ and $2·6 \times 10^{-4}$ for the two solutions. The figures are interesting as glycerin may be utilised for the determination of the moisture of air.

American Floating Dry Docks.—We read in *The Iron Age* that contracts for eight 10,000-ton floating dry docks to be built by the Emergency Fleet Corporation and sold to private companies are now in the hands of the legal department of the United States Shipping Board, Washington, and probably will be formally approved and signed within a few days. The docks are to be constructed of wood. They will be sold to four companies, who will operate them in conjunction with complete ship repair plants. These companies are the Norfolk and Hampton Roads Ship Repair and Dry Dock Corporation, Norfolk, Va.; Fraser, Brace and Co., New York; the Ramberg Iron Works, Incorporated, Brooklyn; and the Perth Amboy Dry Dock Company, Perth Amboy, N.J. Each company will receive two dry docks. The docks will cost 800,000 dols. each and will be built in the shipyards of the following companies: Narragansett Shipbuilding Company, Tiverton, R.I.; Kingston Shipbuilding Company, Kingston, N.Y.; Atlantic Gulf and Pacific Company, New York; and W. H. Gahagan, Incorporated, Arverne, Long Island. One of the problems of the Shipping Board for some time has been to provide adequate repairing facilities for America's growing merchant marine.

Federation of British Industries.—Sir Arthur Steel Maitland, Bart., M.P., late Under-Secretary of State for Foreign Affairs, additional Parliamentary Secretary to the Board of Trade, and till recently in control of the Department of Overseas Trade, has been invited to become a member of the Overseas Committee of the Federation of British Industries, and has accepted the invitation. The Federation of British Industries is doing everything that lies in its power to help to develop the export trade of the United Kingdom in co-operation with the Department of Overseas Trade. In many countries of the world it is establishing its own commissioners, men of the highest integrity, with knowledge of the local language and customs, and men who have generally spent many years in the areas to which they are appointed. These commissioners will look after the interests of the individual members of the federation, they will exhibit their samples, appoint agents, furnish status reports, and send home information with regard to local demands and intelligence. So far, several million pounds worth of actual inquiries have been received by the federation headquarters in London, from the commissioners abroad. These inquiries have been distributed to the members of the federation interested.

THE MACHINE-TOOL TRADES ASSOCIATION.

The report for the month of July of this association states that the Manufacturers' Committee and the Executive Committee had under consideration the uniform prices clause recommended for adoption by the members in the circular letter under date February 3 last. It was decided to recommend that this clause should be withdrawn, and that wherever possible, firm quotations should now be given, but, if circumstances make it necessary to insert a provision in any tender, the members of both committees were unanimously in favour of using the following clause in place of the old one: "That in view of the present unsettled state of industry it is a condition of all tenders and orders that the contract price is to be increased or reduced by an amount equivalent to the general increase or reduction in wages and materials."

The committee considered the complaint made by one of the members with respect to the refusal of railway companies to accept empty cases for return. It was decided to take up this matter in the appropriate quarters.

Applications for membership from a number of firms were considered, and those of eight firms were approved for submission to the council.

A letter from the Institution of Mechanical Engineers, asking the association to appoint a representative on the Cutting Tools Research Committee of this Institution, was considered, and it was decided that Mr. P. V. Vernon, of Messrs. Alfred Herbert, Limited, should be appointed as the association's representative.

It was reported that in response to the resolution passed in regard to nationalisation, letters of acknowledgment had been received from the Prime Minister, the Federation of British Industries, and the Imperial Commercial Association. It was also reported that the Imperial Commercial Association had decided to approach all associations interested asking them to appoint a representative on the special council to be formed for the purpose of starting a campaign against nationalisation.

A letter received from the Federation of British Industries was read, stating that it was the practice of some foreign firms to invoice goods to their British agency at prices which show only a nominal profit, and that, to avoid this, the federation were of opinion that power should be given to the Inland Revenue authorities to collect income-tax from the agency on a basis of turnover. The committee were of opinion that a better plan would be to tax such agencies according to their size as compared with the proportion of profit made by the parent concern, and it was decided to make this suggestion to the Federation of British Industries.

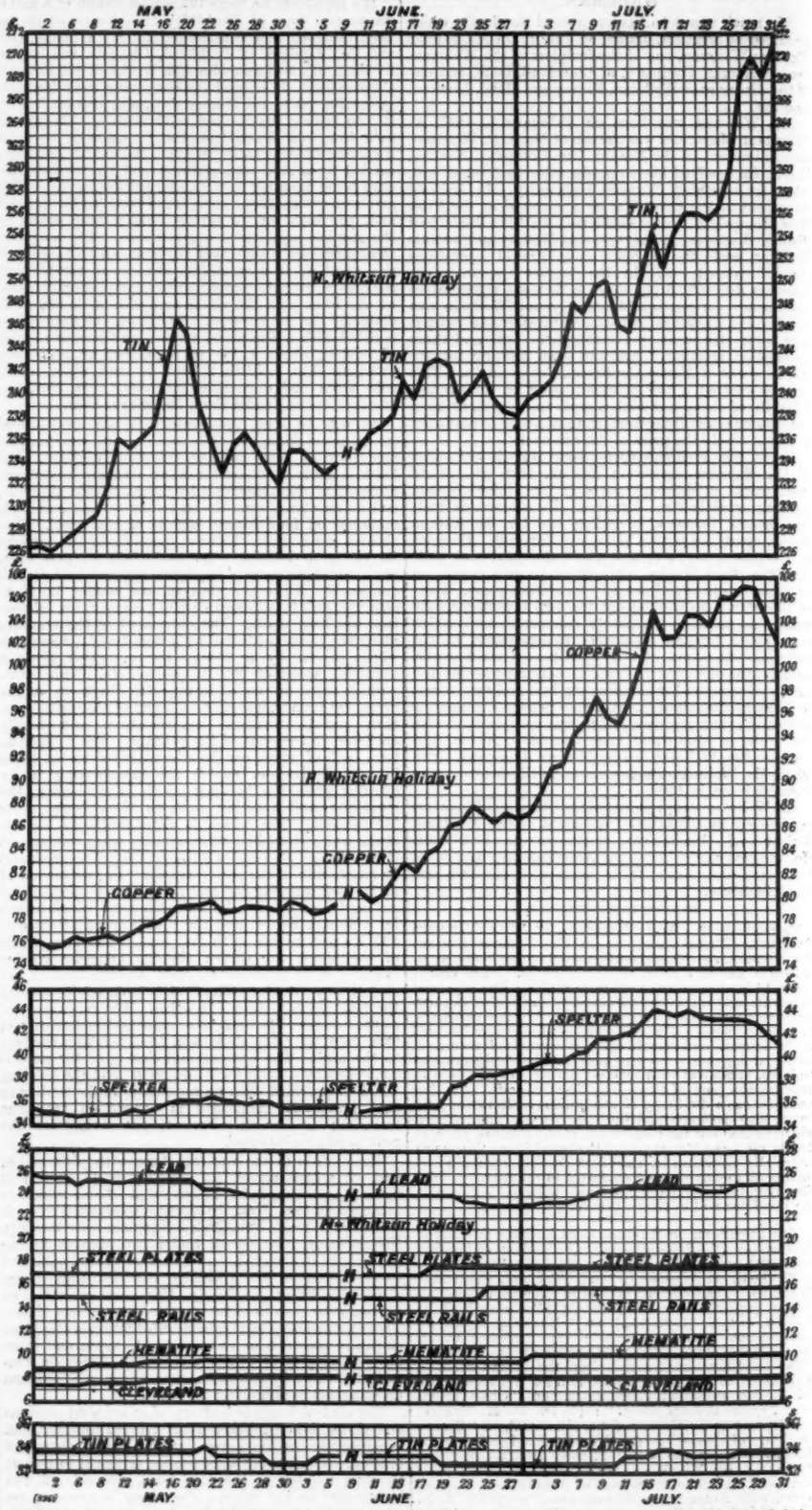
It was reported that the attention of the Federation of British Industries had been drawn to the position in respect of patents and licences under patents in view of the alteration of frontiers caused by the war, and in reply the federation had written that this matter would be carefully gone into by their Patent Law Committee as soon as the new Patent Bill has been introduced into the House of Commons. The question asked in the House of Commons by Sir J. Norton Griffiths, and the reply given by Mr. Bridgman was also reported. The committee were satisfied that the Government were giving attention to the matter, and that therefore no further action was necessary. The assistant secretary reported that he had attended a meeting of the Imperial Institute of Patentees at the Cannon-street Hotel, when the following resolution was adopted for submission by deputation to the President of the Board of Trade: "That this meeting approves the formation of an organisation to safeguard and promote the interests of patentees, and pledges itself to united action, in the duty of using all legitimate means to obtain from Parliament an extension of the life of patents which have been prevented from working and developing in consequence of the war, and expresses its opinion that an alteration in the law is desirable in the interests of manufacturers and for the purposes of reconstruction."

In view of complaints that under paragraph 3 of the Railway Companies Consignment Notes the companies disclaim liability for delay, &c., in the event of goods being handed to another railway company if the claim is not made in writing within 14 days after the receipt of the goods by the first contracting firm, the committee were of opinion that the enforcement of this condition was both unreasonable and practically impossible of fulfilment, and it was decided that the matter should be taken up with the Railway Clearing House with a view to the alteration of this clause.

The late Mr. John Henry Sands.—We regret to have to announce the death, on July 28, after a lingering illness, of Mr. John Henry Sands, a director of Messrs. George Sands and Son, Limited, constructional engineers, Colwick, members of the Engineering Employers' Federation and of the British Engineers' Association. Mr. Sands resided at Suthe land-road, Sneinton Hill, Nottingham, and was well known in Midland engineering circles; he was about 55 years of age, and leaves a widow and three sons.

Personal.—Messrs. Drake and Gorham, Limited, have disposed of their wholesale trade department to a separate company. In view of the goodwill attaching to the name, permission has been granted to the new company to continue its use, and it has therefore been registered as Drake and Gorham Wholesale, Limited, with registered offices at 67, Long Acre, W.C. 2, to which address all letters relating to wholesale business should be sent.—Mr. Mario Tansini, consulting engineer, has removed from 37, Lime-street, to Copthall House, 13, Copthall-avenue, London, E.C. 2.

DIAGRAMS OF THREE MONTHS' FLUCTUATIONS IN PRICES OF METALS.



Note.—In the diagrams the figures plotted for tin and copper are the official closing cash quotations of the London Metal Exchange for "fine foreign" and "standard" metal respectively. The prices shown for lead are for English metal, whilst those for spelter are for American metal. Middlesbrough prices are plotted for steel plates and rails, and also for hematite and Cleveland pig iron. The prices given, in the case of steel plates, are for ship, bridge, and tank qualities, and those for steel rails are for heavy sections. The pig iron prices are for East Coast hematite and Cleveland iron, both of No. 1 quality and for home consumption. The price of tin-plates is per box of I.C. cokes free on board at Welsh ports, but in all other cases the prices are per ton. Each vertical line in the diagram represents a market-day, and the horizontal lines represent 1*l.* each, except in the case of the diagram relating to tin-plates, where they represent 1*s.* each.

PORTABLE PNEUMATIC GRAIN ELEVATOR; DUCKHAM SYSTEM.

By GEORGE FREDERICK ZIMMER, A.M.I.C.E.

THE Duckham system of handling grain by suction, with its subsequent further developments for more specific purposes of handling, is one of the best known to-day, and is certainly one of the most fascinating. It differs in its fundamental principle from all other handling devices, in so far as no mechanical pushing, carrying, or lifting devices, with their inherent disadvantages, are employed therein, the grain being sucked, as it were, from place to place while floating in a current of air. The rigidity with which most other handling devices are fettered to straight lines and right angles cannot therefore apply here, and the consequent pliability of at least the receiving and delivery ends of such installations—which makes it possible to reach a cargo by the use of a flexible hose—is responsible for the adoption of the system throughout the civilised world for unloading bulk cargoes and small parcels of grain. The expeditious and convenient working shows such marked advantages over other systems as to far outweigh the disadvantage of the greater driving power expended in its use.

The latest application of the suction system consists in mounting such installations upon railway rolling stock; pneumatic suction plants have for years been housed in pontoons and mounted on wheels in order that they may travel at a slow speed along the quay-side—in addition to the many stationary installations. The idea of building them into railway trucks of such size as to conform to the standard loading gauge only materialised shortly before the outbreak of war; the fate of the first installation, which forms the subject of this article, and was built for the Vladikavkas Railway Company of Russia, was at first uncertain, but it has since been ascertained that it was at work when the war broke out.

The engineers who designed and built this plant were the East Ferry-road Engineering Works Company, Limited, of Millwall, London, E.; they have been closely connected with the development of the pneumatic system since its first conception by Mr. Duckham, in fact, they not only built all the experimental plant for him, but their manager, Mr. F. S. Tuckett, carried out, in conjunction with the late Mr. Duckham, many of the elaborate tests which were necessary, between the years of 1888 and 1891, before the details were fully developed.

Since the building of this first plant on railway rolling stock, several similar installations have been built in this country for H.M. Office of Works, in order that such portable plant may be taken, at a few hours' notice, to any dock where grain cargo has to be unloaded, if no other installation is available there. These appliances are mounted in two standard gauge box trucks. The reason why publicity was not given before to the first installation of this kind—the one built for Russia—was the desire to include, together with the description and illustration, an account of its actual performance at its destination; this has not, however, yet come to hand, and it has been thought best not to delay publication any longer as, owing to the unrest in Russia at present, such particulars may not be available for some time to come.

As will be seen from the views on Plate XI, the whole of the plant is housed in one truck 53 ft. long over buffers, this being rendered possible owing to the ample height permissible, which, combined, with the wider gauge of the Russian railway (5-foot gauge) offered a more favourable proposition. Moreover, in the plant illustrated, vertical exhausters are employed; whereas, owing to the restriction of headroom the British installations had to be provided with exhausters of the rotary type, our loading gauge allowing only 13 ft. 6 in. from rail level to the top of the truck, whilst in the Russian installation the distance is 17 ft. 1½ in.

The whole truck with machinery weighs 86 tons. The front end—on right-hand side of illustration—is supported on an 8-wheel bogie, the leading and rear pair of wheels being of the ordinary type, whilst the centre pair can be coupled to the engine so that the truck can travel on its own power at the rate of 5 miles per hour. If the installation is at work, discharging grain, or used as ordinary rolling stock, this driving connection to the front bogie is thrown out of gear. The rear end of the truck rests on a 4-wheel bogie, the distance from centre to centre of bogies being 36 ft. The installation has a capacity of 60 tons per hour when sucking bulk grain from railway trucks and it is capable of blowing the grain a distance of about 100 ft. to an elevation of 25 ft.

We will now briefly enumerate the different parts of the plant as shown in the elevation, Fig. 1, and plan, Fig. 2, and two cross sections, Figs. 3 and 4. Beginning at the right hand, or front end, the "Blackstone" oil engine occupies the first position and alongside it is one of Heenan and Froude's coolers; the engine and the cooler are so situated on the chassis as to balance each other as nearly as possible. The cross section, Fig. 4, gives a view of the engine and its cooler, showing also the oil fuel tank on one side and the silencer on the other; this cross section also shows the clutch by means of which the travelling gear of the truck can be thrown in and out.

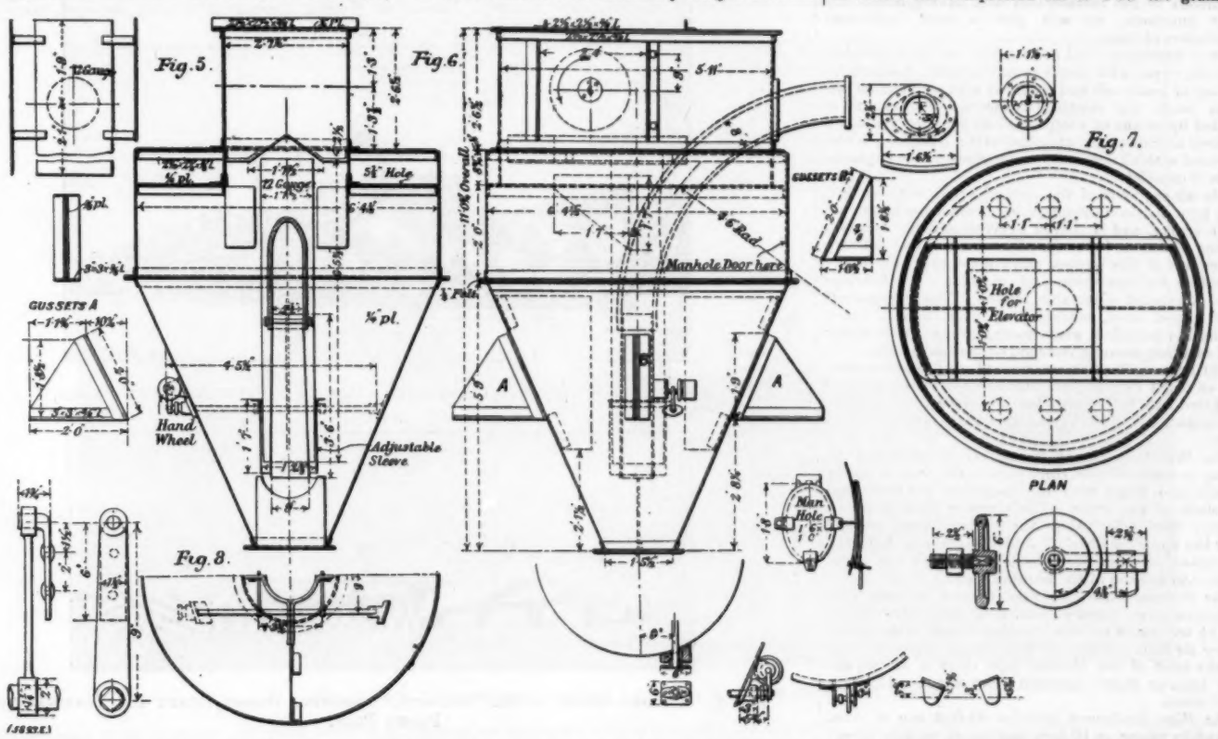
In Fig. 1 the upper of the two shafts seen near the front end, is the main engine crank shaft; this is coupled through a "Hele-Shaw" friction clutch and a Westinghouse silent chain drive to the main shaft which runs centrally through the railway truck as shown in Figs. 3 and 4. The propelling gear is also seen in Figs. 1 and 4, and the Oldham universal coupling at the point X permits of slight motion between the centre of the front bogie and the vertical driving spindle. If the plant is to be set in motion the claw clutch A is thrown into gear previous to the Hele-Shaw clutch B, and the travelling gear is disconnected; the clutch, B, can then be engaged.

The exhauster, which comes next, occupies a central position and takes up the greater part of the truck. The cross section, Fig. 3, through the truck, gives an end view of the exhauster. The larger pipe leading from it is the suction pipe, and the smaller one is the compressed air pipe; the blowing tank behind the exhauster is also visible with the air inlet, and just above this pipe (11 ft. 5 in. above the ground) is the delivery pipe, from which the grain and air can be led a distance of 100 ft. by portable pipes.

Adjacent to the air pump we have the blowing tank, which is connected to the compressed air pipe of the exhauster and which is fitted at the top with a revolving wheel valve through which the grain enters without permitting an escape of compressed air. The blowing tank is also fitted at the bottom with a special valve to enable the compressed air to blow the grain out through the delivery pipe previously mentioned above. Next in turn comes a bucket elevator, the receiving end of which is also fitted with a revolving wheel valve, the upper part being in connection with the suction chamber or canister in which is created a vacuum of about 5 in. It will thus be clear that the suction and the blowing tank are connected by the elevator, the two terminals of which receive and deliver their charges through revolving wheel valves. The suction-chamber is connected at the upper end to two 6-in. pipes through which the grain enters and is deposited by two trumpet-shaped pipes. The suction pipe, between the canister and exhauster, is shown in dotted lines as leading from the exhauster, both in plan and elevation. So far as the grain handling is concerned this practically completes the apparatus.

At the rear end of the truck will be seen a small oil engine which drives at will a small lighting plant, or an auxiliary compressor which is used for starting the main engine. For this latter purpose there are two compressed air cylinders which may be seen in cross section, Fig. 3. Close to this auxiliary engine is the cooling water tank for the circulating pump of the compressor, while above this engine the oil-tank for the same is shown, and the filler cap for the water-tank.

The *modus operandi* is as follows: The exhaust produces a partial vacuum in the suction chamber which causes the grain to enter by two flexible pipes with the usual nozzles at their ends. The grain is delivered by the two trumpet pipes near the base of this chamber and is withdrawn through a revolving wheel valve without destroying the vacuum. After leaving this valve the grain enters a short, fully enclosed bucket elevator, which delivers its load



through a similar wheel valve into the top of the blowing tank, the pressure in this chamber is 5 lb. to the square inch and is sufficient to force the grain out through a pipe into the open (where it is generally delivered underneath a large sheet of tarpaulin), or into the granary.

No dust collectors are required in connection with this plant, and although the Russian wheat we receive in this country is reckoned one of the dirtiest, *i.e.*, containing the greatest percentage of impurities, it is evidently pretty free from dust in the country of its origin, and the impurities are possibly added to bring the percentage up to the allowable limit for export purposes. It will be understood that with the plant under consideration, in which the grain is handled both by suction and compression, these two distinct processes must be carefully synchronised, and to this end the pressure nozzle has an adjustable sleeve similar to the suction nozzle, by means of which its capacity can be regulated. Moreover the capacity of each link in the process is so tuned up as to ensure each successive one being just a trifle larger than that preceding it.

Having now dealt generally with each machine and apparatus of the installation, and having mentioned their functions, we will give a brief individual description of them.

The "Blackstone" oil Engine is of the four-cylinder, vertical, type, with water-cooled jackets, designed for the use of crude oil and provided with a clutch on the main shaft for starting purposes. The engine is started by means of compressed air supplied through a receiver and air-pump attached to it; a radiator is also provided with all necessary connections to the engine to make it complete.

The air-engine is of the vertical type, water-cooled, with two cast-iron cylinders 30-in. diameter having an 18-in. stroke, and is driven by Westinghouse noiseless driving chains and wheels. The suction and delivery valves are of the poppet valve plate type, all easily accessible for inspection and cleaning. All bearings have gun-metal adjustable brasses. The crank-shaft is of forged steel, machined all over, and a heavy flywheel is provided, with barring gear; the bedplate is of cast iron securely fastened to the underframe.

The Receiver Tank is constructed of ¼-in. steel plate and stiffened with angles. On the top of the receiver are fitted two bell-mouth suction pipes with quarter-bends made to swivel, having the necessary 6-in. suction pipes.

The Bucket Elevator is completely enclosed and the casing is made of ⅛-in. steel plate; the boot is partly of cast-iron, fitted with adjusting gear for taking up the slack of the chain. The elevator buckets are of pressed steel, attached to the endless chain, passing over the sprocket wheels. And the grain is delivered by means of a shoot with slides through the wheel valve into the top of the blowing tank.

The Blowing Tank, see Figs. 5 to 8, on page 191, is likewise constructed of ¼-in. steel plates with 2½ in. by 2½ in. by ⅜ in. steel angles fitted with patent rotary air-lock similar to that on the suction tank. At the inlet of the blowing pipe there is an adjustable annular sleeve operated from the outside by a hand-wheel.

The Pipe Equipment includes 80-feet run of 6-in. Armadillo piping in 10-foot lengths, as suction pipes; 50-feet run of 8-in. Armadillo piping in 10-foot lengths, as delivery pipes, and 150 ft. of 8-in. steel pipes in 10-foot lengths; four 6-in. normal suction nozzles, and four 6-in. "camel-back" nozzles, for reaching more inaccessible parts of the grain cargo.

The Auxiliary Oil Engine is of 7½ brake horse-power, running at 720 r.p.m., and driving a vertical duplex air-compressor, having a displacement of 19 cub. feet per minute when running at 400 r.p.m., the driving gears being arranged with a sliding pinion so that this compressor can be thrown out of action when not required. Coupled to the other end of this engine is a continuous current dynamo of 36 kw. at 120 volts, the whole being mounted on a combination bedplate. Such accessories as the shunt regulator for the dynamo and the circulating pump for the engine are also provided, which latter circulates the water first round the compressor and afterwards round the engine.

British Shipbuilding for France.—The Compagnie Générale Transatlantique has placed an order for a high-class steamer of 20,000 tons displacement with Messrs. Cammell Laird and Co., Limited. The vessel will be built, engined, boilered and completed in all details at Birkenhead, where it will be laid down as soon as a berth is available. The propelling machinery is to consist of double reduction geared turbines.

United States Manganese Ore.—The statistics issued by Mr. D. F. Hawett, United States Geological Survey, show that the domestic production of high-grade manganese ore for the last quarter of 1918 were 75,465 tons, as compared with 90,738 tons, 82,481 tons and 55,682 tons for the third, second and first quarters respectively, making a total for the year of 304,366 tons, or 2½ times the total for the preceding year.

THE DAZZLE PAINTING OF SHIPS.*

By Lieut.-Commander Norman Wilkinson, R.N.V.R.

The paper I am about to read to you deals with the origin and development of dazzle painting, and I shall endeavour to show the reasons for its adoption as opposed to painting a ship with a view to achieving invisibility. At first sight it would appear that the latter was the sound line to take when seeking to render a ship immune from submarine attack, but on examination I think I can show you the fallacy of painting a vessel in this manner.

Dazzle painting is a method to produce an effect (by paint) in such a way that all accepted forms of a ship are broken up by masses of strongly contrasted colour, consequently making it a matter of difficulty for a submarine to decide on the exact course of the vessel to be attacked.

I shall hope to show you that so-called invisibility against submarine attack is not only impossible, but dangerous, and consequently, if a vessel can be seen at all it does not matter how visible she is, providing her course remains a matter of question to the attacker.

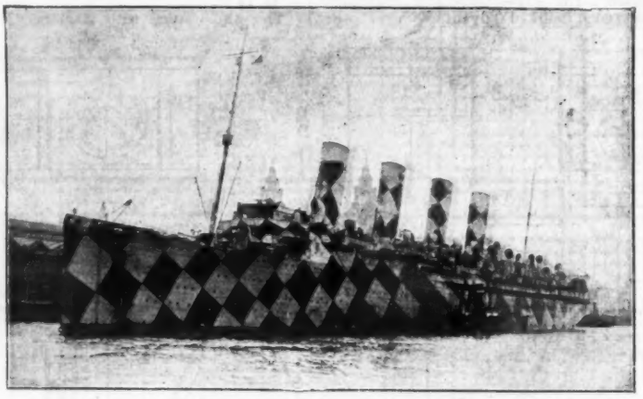


Fig. 1. SS. "Mauretania," showing "Cheque" Pattern Dazzle Design.

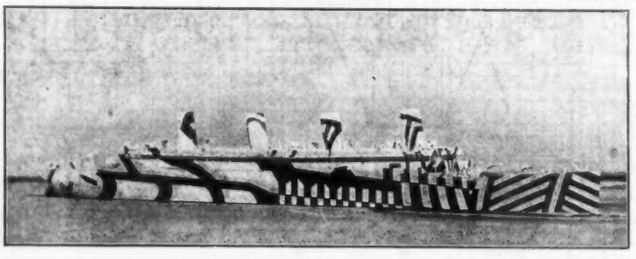


Fig. 2. Wooden Model of SS. "Olympic," showing Design Ready for Transfer to Paper Plan.

The accurate determination of a vessel's course is the prime factor required by a submarine commander to ensure successful attack.

Many animals and birds are provided by nature with an external scheme of colouring which harmonises with their surroundings in such a way as to make them practically invisible to an enemy so long as they are in a state of rest. This applies to a number of animals more or less immune from attack, and is provided in order that they may lie in wait for unsuspecting prey.

All the previous attempts which have been made to utilise paints as a defensive measure when dealing with ships were made with a view to rendering them invisible. Land camouflage as practised in the theatres of war has developed along the lines of protective colouring or invisibility, and has reached a remarkable pitch of perfection. It is not difficult to see the reason for this. When desirous of hiding any particular object such as a battery of guns from the enemy, you are more or less assured of surroundings of a broken nature, little likely to be subject to a change of colour, and, providing you can successfully imitate these surroundings by covering your battery with fabric &c., you have practically achieved your end. There is, of course, a highly technical side to this work, and some of our most skilled artists have been working on the problems presented throughout the war; but these I will not go into now, as it has little or no bearing on the special form of camouflage I am about to deal with.

If we turn again to sea camouflage, *i.e.*, the painting of ships as a defensive measure, we find an entirely different order of things. Firstly, the ship is in motion; secondly, you have two elements, sea and sky, subject to constant changes of colour and light; thirdly, there is the horizon, a most difficult problem to deal with, which is either a hard clear-cut edge against a brilliant sky, or elusive and blurred. Conditions vary greatly according to the particular part of the globe under survey.

Let us take two localities characteristic of these conditions, and also as being the great hunting grounds of the enemy submarine during the war, viz., the Mediterranean, and the coast of Great Britain. You find, generally speaking, the weather conditions in the first named are clear sky, dark sea, with sharply defined horizon, while round the British coast you get a softer horizon, and less contrast between sea and sky, due to moisture in the atmosphere, and other local conditions. I speak with some experience, having been a marine painter with long experience at sea, and constant observation of weather, colour, &c. Now it will be at once apparent that a ship painted with a view to obtaining invisibility in one locality has very little chance of being successful in the other, and having once been seen by a submarine, from that moment loses any defensive qualities paint can give her.

Let us suppose you are setting out to paint a ship in order to bring about invisibility. You first of all require her hull to be in a fairly clean condition as you are intending to paint her in very light delicate shades of colour. Assuming the very unlikely case of getting your vessel in this condition you commence work. On the second day, when you are well on with your painting, a coal lighter come alongside, and as the life of the country is dependent on the ship getting to sea you cannot stop this operation. Therefore, your clean paint has a film of coal dust of varying intensity all over it. She has then to take in or discharge cargo, with its consequent wear and tear of paint; warps or tenders are rubbing her, scupper pipes and endless exhausts trickle down her sides, which make it impossible to paint here at all. However, having got over these difficulties as best you can she goes to sea. Now comes a further trial; her hawse pipes run streaks of rust down either bow and her water line becomes rusty, or is coated with oil deposit from her stay in port; and, finally, you cannot expect her short-handed crew to devote hours of their time to constantly re-painting her to your exact shades of subtle colour. Assuming, however, that you do get her to sea in perfect condition as regards paint, can you make her smoke invisible? With a following wind this smoke will ascend hundreds of feet into the air, quite possibly at a time when a watchful submarine is looking out for prey, he doesn't need to look for your invisible ship, he knows she is there and has an easy job.

All these difficulties were practically non-existent with the dazzled ship; the requirements in her case were strong contrasts of colour, and even though your light colours were dirty the juxtaposition of black made them appear clean by comparison. I have seen an old tramp steamer in the London Docks which had not had a touch of new paint on her dazzle scheme for five months, and the effect of the distortion was perfectly good. Had she been painted for invisibility scarcely anything would have remained of her scheme, and the most pronounced optimist could not have claimed that she suggested anything of an invisible nature. It always struck me that the dazzled ships seemed cleaner than an "all one coloured" ship on the principle that a

* Paper read before the North-East Coast Institution of Engineers and Shipbuilders, July 10, 1919.

white table cloth will look dirty sooner than a patchwork quilt.

It appears to me that one reason for the continued attemps to obtain invisibility at sea has been largely contributed to by the fact that vessels are nearly always seen from the bridge or look-out of another vessel, or from a shore station, all of which vantage points are a considerable height above the sea level, thus giving the observer a sea background of a fairly dark tone. Now the submarine point of view is entirely different. He sees every ship against a sky background only, with practically no foreground of water which is a very different proposition.

A ship seen from another vessel's bridge may, under certain weather conditions, achieve a partial degree of invisibility when the colour of the ship's hull and that of the sea happen to coincide. But this same ship, seen at the same time by a submarine, will appear as a darkish silhouette against the sky. This partial invisibility will only be gained in small vessels of the cargo type, where there are no promenade or hurricane decks, or other structures liable to cast shadows.

At the commencement of the scheme I was frequently told that invisibility could be gained by the application of Thayer's Law of Shadow Elimination, and that if you painted the undersides of a passenger deck white, you could overcome these deep shadows. This I can definitely state to be a fallacy. No paint which is in itself dependent on the sky for light can overcome a shadow of this density. There is one instance where white paint can be utilised to overcome shadow, and is sometimes useful. This is on a vessel with a marked flare to the bow. By painting the upper portion of the hull with white and the lower part a grey or blue, the appearance of the flare can be largely neutralised. This treatment often tends to alter the character of the vessel in a marked way by flattening the bow. The reason for the success of this measure is owing to the strong reflected light cast upwards on to the flare of the bow, and consequent illumination of the white paint. This applies more forcibly when the vessel is under weigh.

An important argument against invisibility at sea is the smoke. Where there is an unlimited supply of hard coal, or the vessel is oil burning, you may overcome this difficulty to a certain extent; but there will be times when any vessel will show smoke, so that even if it were possible to achieve complete invisibility of hull, it might be at that moment that her position would be disclosed to an enemy submarine on the look-out. I suggested to the Admiralty in the early stages of dazzle painting that the question of a vessel's smoke should be gone into with a view to obtaining a really efficient smoke destructor, such as you have in a shore factory, in that it would prevent a vessel, hull down, from being observed. Where you have a ship with a following wind, burning soft coal, her smoke will ascend vertically and make her presence known at a great distance. Two further strong arguments against obtaining invisibility are the bow wave and the stern wash, both of which I saw no way of overcoming.

I have attempted to give you one or two reasons showing why, in my opinion, any attempt to gain invisibility of a ship at sea by means of paint is bound to fail. There remains, however, one more factor which I think finally disposes of the last vestige of chance in this direction. This is the director hydrophone. This instrument puts the vessel painted for invisibility more or less in the position of the ostrich. We knew the Germans had developed the hydrophone to a high state of efficiency, and were able by its use, to decide not only on the probable class of a single ship, or a number of ships roughly, if in convoy, but could by a series of listening observations, obtain the general direction in which the ship or convoy was proceeding. This is naturally only approximate, but will be of considerable help in the very early stages of the attack. After deciding on the direction, the submarine will rise and commence visual work with the periscope, and it is from this moment that the ship painted all one light colour, or in a series of small spots or parti-coloured paint, becomes a comparatively easy prey; and although she may be zigzagging, her course can be determined far more easily than a vessel painted in the way I shall describe. This determination, of course, is the prime factor required by a submarine when making an attack.

It was from the moment that I realise the hopelessness of obtaining invisibility that it seemed to me something could be done with paint on entirely different lines. At the time my proposal was put forward all transports were painted black from waterline to truck. I was continually on patrol in the Channel in May, 1917, and it struck me that of all the colours that could have been chosen this was the most dangerous. A submarine commander, had he been given the choice of colours to ensure successful attack, would most certainly have decided on black both for day or night. My reason for relying on paint was the knowledge that the employment of fabrics, such as netting, gauze or the numerous other articles used in land camouflage were impracticable. Endless propositions of this nature were put forward by people interested in the question of invisibility, but in nearly every case those making them had little experience of the sea and of its ways, and did not realise its power.

Another factor not remembered by many, even when experienced, is the human element. The sailor is temperamentally conservative. You may rig endless devices in harbour and make your ships as invisible as you can, but 24 hours out of harbour they may be swept by a gale (or even a strong breeze will suffice) and what remains of your canvas stripe and muslin trimmings? Not a shred! Does the sailor, believing in your schemes, painstakingly re-rig your pet devices? If I know anything of him, he does not. If he is sunk, he is sunk; but he will not put in half his watch below replacing your fancy fittings. It will be seen, therefore, that paint was the only practical means of disguise which could be applied to the hull of a vessel in such times of stress.

There are, of course, certain important and simple structural additions of a permanent nature which can be made, if time permits, to increase the difficulties of an attacking submarine, but these I will touch on later.

It was the knowledge that the all important factor to a submarine commander was the determination of a ship's course, which gave me the idea that if the accepted form of a vessel could be so completely broken up by contrasting colours and tones of paint as to destroy her outline and general shape, a large point would have been gained towards increasing the difficulties of attack.

The primary object of this scheme was not so much to cause the enemy to miss his shot when actually in firing position (although this has happened in a number of cases), but to mislead him, when the ship was first sighted, as to the correct position to take up.

With a vessel of 10 knots or over, a submarine, having once failed to obtain a good position has little or no likelihood of regaining that position, owing to insufficient underwater speed. Should he decide to come up and overtake the ship by surface speed, the ship attacked, being armed, has every chance of a successful escape, and I should consider it a great testimonial to the painting that it had brought the enemy to the surface.

In submitting this scheme to the Admiralty I made no claim that a ship so painted was certain of escape but simply that she must present a more difficult proposition to a submarine, and could not be easier than an "all grey ship." Another point was that it meant little or no delay to the vessel, as every ship must be painted for weather protection. The fact that nothing of a structural alteration was required was important, and finally, the cost was negligible, as upwards of 100 vessels could be painted for the cost of one good class cargo boat and cargo.

The Admiralty immediately placed a vessel at my disposal for the purpose of experiment. This particular ship, H.M.S. Industry, was employed on a regular run between Plymouth, Portsmouth, Pembroke, Chatham and Queenstown, and therefore constantly in the danger zone. She was painted to a design I had prepared; completed in three days whilst loading, and she sailed to schedule time.

Orders were meanwhile issued to all Navy vessels and shore stations to report on her appearance, when met with; but, knowing the length of time these reports would take to filter through, and also that this first design could not be all I wished, I at once approached the Admiralty for a larger development of the scheme in order to get more frequent reports. Within a day or two 50 transports were ordered to be painted as rapidly as opportunity offered. Each of these vessels was painted differently in order to prevent the enemy becoming accustomed to any particular design. Some designs were, of course, more successful than others, and I eliminated those which were reported on as not giving the required distortion. Some time before the end of the war we had arrived at the striped type of design which was the most successful type. These striped designs were commented on by a great number of seamen as being by far the best for upsetting the calculation of a ship's course. They not only succeeded in breaking up the above-water structures of a vessel very successfully, but also had the advantage of being practically fool proof in application—a most important point. In the early stages of the scheme before we were able to collect and train a staff of outport officers we had considerable difficulty in getting the designs intelligently applied, as it largely depended on the personality of the particular foreman in charge of a job whether the design was a success or not. But I found that these foreman painters very soon became highly interested in the work as soon as they thoroughly understood its meaning, and later became of the greatest assistance in carrying through the scheme. I attribute this very largely to the fact that, as far as my observation goes, every foreman painter has a feeling deep down that he is by instinct an artist who happens to be dealing with art in a broader sense than the ordinary picture painter. This at least has been borne in on me by confidences I have received during visits to ships in the course of painting.

The method of procedure by which the ships became painted will probably be interesting.

In the initial stages a small wooden model of each ship was made to scale. On this a design was painted

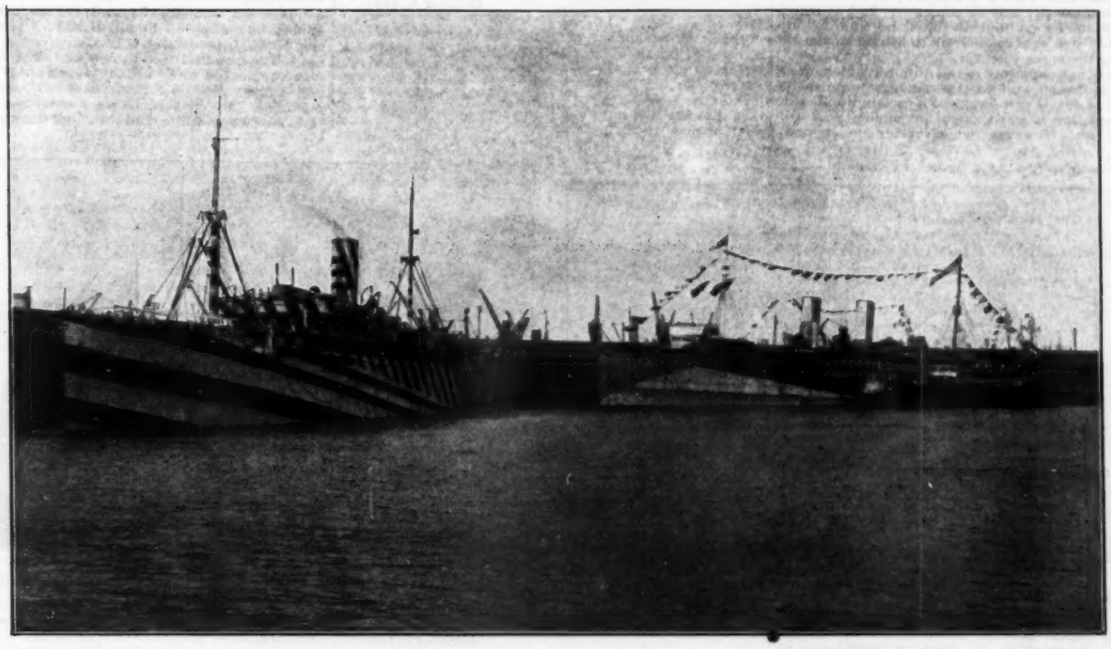


FIG. 3. SS. "GRANTULLY CASTLE." A GOOD EXAMPLE OF STRIPE DESIGN.

in wash colours for the purposes of rapid alteration. This model was then carefully studied on a prepared theatre through a submarine periscope, various sky backgrounds being placed behind her alternately. A satisfactory design having been evolved giving the maximum distortion, the model was then handed to a trained plan maker and copied on to a $\frac{1}{72}$-in. scale profile plan of the ship on white paper showing port and starboard side. The plan was then sent to the outport officer at the port at which the particular ship was lying and transferred under his supervision to the ship. With the extension of the scheme to the whole mercantile marine it became impossible to make a model and plan for every ship, and I determined to divide the Mercantile Marine into typical classes of vessels. For each type of ship a number of designs was made according to the demand for the particular class, and each outport officer was kept supplied with all designs so that on the arrival of a ship requiring a plan he was able to select one which fitted her as nearly as possible. This scheme worked wonderfully well, but needed a great deal of skilled supervision in the early stages, as with a ship, say 350 ft. long and a plan of 380 ft., the work could not be left to be dealt with by a foreman painter. When the scheme had been in operation for some time many of these foremen became so interested and keen that we were able to leave the adaptation of a plan to a ship of different length to them—in a number of cases with conspicuous success. These men were a great help, as the bulk of work grew enormously, and we sometimes had as many as 100 vessels being painted at the same time in one port, with only two or three officers to attend to the lot and with long distances to cover.

At first, although explained in the Admiralty Memorandum, some confusion still existed amongst seamen as to the object of dazzle painting, and a certain number of reports showed that it was thought invisibility was still being aimed at. However, when better understood, almost every report showed that the new scheme of painting was accepted as an effective contrivance in assisting to combat the submarine. From a large number of reports it could be seen that the idea of making the course difficult to determine had been thoroughly grasped. I will give one or two of these, as illustrating the way in which the new form of painting was received.

H.M.S. Martin,
September 27, 1917.

"Sighted oiler Clam about six miles, four points on starboard bow, and for some time could make nothing of her. When about four miles distant, I decided it was a tug towing a lighter with a short drift of tow rope. The lighter, towing badly and working to the windward, appeared to be steering an opposite course.

"It was not until she was within half a mile that I could make out she was one ship steering a course at right angles, crossing from starboard to port. The dark painted stripes on her after part made her stern appear her bow, and a broad cut of green paint amidships looked like a patch of water. The weather was bright and visibility good; this was the best camouflage I have ever seen."

Report on H.M.S. Ebro from H.M.Y. Sayonara.
October 1, 1919.

"September 25, 9.55 a.m., sighted H.M.S. Ebro in the Sound of Mull on the port bow, and on.

"She appeared to alter course to port immediately after and seemed to continue to do so, whereas, in reality, she was altering her course to starboard.

"I should think confusion would be caused in aiming gun or torpedo.

"I was so sure that she was trying to cross my bows that I was on the point of stopping my engines and going full speed astern to avoid a collision, when I discovered that she was altering course to starboard. After passing the vessel it was almost impossible to say how she was steering."

H.M.S. Mischief,
October 18, 1917.

"Sir,—I desire to bring to your notice the following facts:—

"At about 9.30 a.m. on Wednesday, October 17, whilst proceeding up the Firth of Clyde in H.M.S. Mischief, I observed a convoy of some eight ships, oilers, &c., proceeding to sea in a single line ahead.

"No. 6 in the line was 'dazzle-painted,' and appeared to me to be steering at least eight points different to the other ships in the line. So remarkable was this optical illusion that I sent for all my officers and asked their opinion as to the course of the ship. Not one officer agreed within four points. This optical illusion remained until the ship in question was past our beam, when it was seen that she was steering the same course as the others.

"I have the honour to be, &c.,
(Signed) Cyril Ward, Commander.

S.N.O. Ardrossan,
September 25, 1917.

Vessels unknown.

In all cases, more especially when viewed at a distance of about three miles, the vessels presented an appearance of being grotesquely out of all proportion; infinitely more so when the sun shone directly upon them. When approaching, it was not until the vessels was quite near that it was possible to see their bows, even when quite close; at about half a mile the bows seemed to be directly under the bridge. The deception as to distance between bow and bridge, which in all cases appeared extremely high, was indeed remarkable.

Off South Rock Lightship,
October 6, 1917.

Clam.

Effect of camouflage painting was that the vessel, at a distance of about two to three miles, appeared as a wreck on her beam ends, and patches of paint on bows caused absence of perspective. It was difficult to locate the vessel's stern. This was increased by the fact that she had only one thin short mast placed well abaft the centre of the ship.

H.M.T. Anzac,
August 15, 1917.

Ocean Monarch.

(a) No apparent difference was noticed in speed, but the course she was steering was particularly deceptive. At times, principally when viewed from ahead, she appeared to be steering as much as six points to port of her actual course, my attention being called by my second hand on two occasions when he thought this was actually taking place.

(b) It was difficult to tell what type of ship she was. At times she appeared to be only half a ship, i.e., a vessel with her bow and stern cut off.

(c) When I was right ahead of her, and she was heading directly towards me, sun right ahead of her as before, she appeared to be heading six points off her course to port.

Captain Barttelot,
September 25, 1917.

SS. Millais.

"Convoy was observed by three destroyer officers running trials at distances varying from two to four miles.

"All three officers agree that the 'dazzle painting' of the Millais was a huge success. They state that it was quite impossible to state her course, even approximately, except when the sun lit up her masts. Lieut.-Commander Harrison stated he could not tell her course within 12 points."

H.M.S. Mantua,
13 O.B. Convoy Section.

"The dazzle scheme on the starboard side of Ascanius is excellent. The ship sometimes appears to be going in the opposite direction, and in misty weather her course cannot be judged within 8 points.

"On a bright moonlight night she was invisible at one mile.

"I am strongly of opinion that all ships should be painted on these lines."

As a result of these, and a large number of other reports, it was decided by the Admiralty in October, 1917, under the Defence of the Realm Act, to paint the whole British Mercantile Marine and a considerable number of war vessels employed on convoy and other duty. The Admiralty Memorandum on the subject may here be reproduced:—

Instructions to "Dazzle" Officers.

"It has been decided to paint all merchant vessels and armed merchant ships, and certain of H.M. ships, with the "dazzle" scheme of painting.

This scheme is based upon the principle that invisibility at sea being unattainable, some protection may be afforded by painting ships in such a way as to confuse an enemy submarine, and, by causing doubts as to the course, speed and distance, thus delay the discharge of the torpedo and cause uncertainty of aim.

A number of designs are in preparation which will enable a suitable plan to be selected for any particular ship that may come in hand for refit or painting.

Officers are being selected who will represent the Director of Naval Equipment at all the principal shipping ports, and who will be furnished with plans prepared at the Admiralty."

For a time, in the early stages of the scheme, I hesitated to use white paint for various reasons, but after considerable experience it was found to be the best "colour" for those parts of the ship intended to be invisible. I will read you a few remarks on white paint from one of my officers:—

Belfast,
February 3, 1918.

Submitted:—

"Between January 31 and February 1, I took the opportunity of proceeding in H.M.Y. Albion III to view the appearance of the O.B. Convoy No. 44 while at sea. The weather conditions on this occasion were fairly typical of those usually experienced in the North Sea, namely: Wind S.E., force 4 to 6, sea 4, visibility 3-5 miles. My conclusions were as follows:—

(1) That when white had been used extensively in a dazzle design, by far the best results appear to be obtained.

(2) That the best dazzled ship in the convoy was the ss. Demosthenes. The power of hull design chiefly lies in the large amount of white employed on the upper portion of her bows and bridge. From a number of points of view this white portion appeared to be a part of the midship superstructure producing a very confusing effect, it being quite impossible to make out the ship's course, or to discover the form of the bridge.

(3) That the design of the port side (I did not see the starboard side) of the ss. Botanist would have been improved had more white been used on some parts. From the bridge to a point abaft the funnel where white was prominent in juxtaposition to dark colours, a most awkward appearance was produced, but too large a portion of the painting of the hull aft was very weak, which helped to make judgment easier as to course of ship. I believe that some white about this portion would have much improved the design as a whole.

(4) That the design on the ss. Colonial was not very effective. The contrasts between the colours used were not nearly intense enough, suggesting the requirement for some white.

(5) That the stern and outline of stern should be broken up by colours in strongest contrast, always including white. The white as schemed in bows of ss. Demosthenes supports this view, and the officers of the Albion III spoke of a dazzled ship they had seen with poop cut off by white. The white, they say, completely destroyed the outline of the stern, and was mainly responsible for their having come to the decision that the ship was the best dazzled one they had seen."

Although I have told you that from my point of view it is impossible to obtain invisibility by painting, it is nevertheless possible to render parts of a vessel relatively invisible by contrast, and this is a large factor in "dazzle" painting.

The best method for achieving this is by painting your light parts of a design with two light colours, varying definitely in tone. By this I do not mean a blend of two colours in spots or squares, but in definite flat tones of each.

To deal first with the starboard side—

Divide the vessel amidships; paint the fore end white,

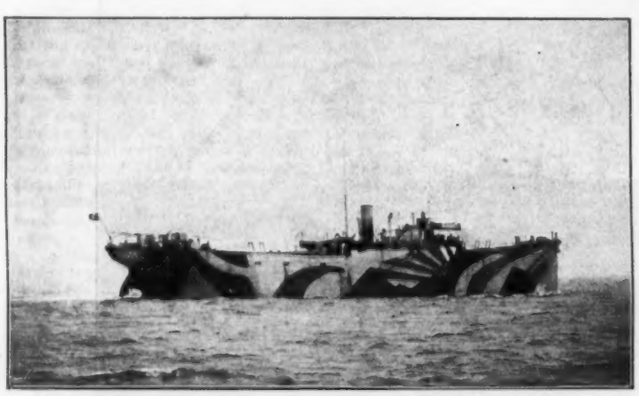


Fig. 4. Standard Ship "War Python." Starboard Side.

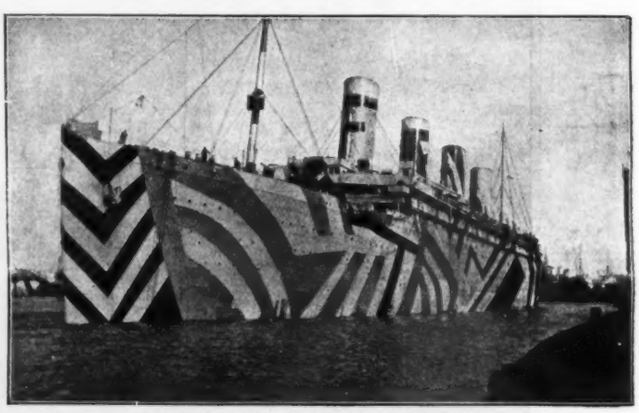


Fig. 5. SS. "Olympic," Showing Port Side Design.

and the after end say, No. 2 blue. On the port side—fore end No. 2 blue, and after end white.

This is the broad principle, but is subject to certain modifications. For instance, a colour should never be allowed to stop an important constructional point, such as the stem or centre of stern; consequently, either the white on starboard or the blue on port side should be carried round the bow until checked by part of the dark pattern, and the same at the stern.

The reason for painting the ship in two tones of light colour was that there is a far greater chance of one of them harmonising with the sky behind, and thus giving great distortion to the vessel when used in conjunction with black or dark greys.

It may be said: Why not paint the vessel in a number of sectors of different tones? The reason for not doing so is that you must have large masses of simple colour if you desire to carry long distances. It was found early in the stages of dazzle painting that a number of light colours in close juxtaposition simply meant a great increase in the labour of marking a ship out, and the cost of painting, without achieving any better result than that obtained by two simple masses of ligh colour.

A number of various light paints on the ship's side after exposure to weather, and the rough handling they are bound to be subject to, becomes reduced to one light tone of a neutral tint, and is no more effective than giving the parts you require to be light a single colour.

Coaling is only one of the operations which rapidly reduce subtleties to nothing, and with the urgency and rapidity with which ships were handled in ports during the war, you could not indulge in elaborate schemes of painting requiring constant attention. If you are to deal with large numbers of ships it is essential that whatever scheme is adopted should be simple of application. I have found that although the scheme is reduced to the simplest possible method, it requires constant attention and inspection to ensure vessels being painted in keeping with the plans. The simpler your design, the greater degree of distortion you can achieve.

The most important parts of a ship on which to obtain distortion are in the neighbourhood of the stem and the forebridge, both of these being of great use to a submarine in determining the course. Where a ship was being painted against time, these parts were attended to first.

The colours mostly in use were black, white, blue and green, either in their primary condition, or mixed to various tones. When making a design for a vessel, vertical lines were largely avoided. Sloping lines, curves and stripes are by far the best and give the greater distortion. Under proper supervision the process of marking out a ship was soon learned by the foremen painters. As an instance the Leviathan, ex Vaterland, was marked out in just over two days, and it should be remembered that she is a very extreme type. The fact that she took a considerable time to paint was due to the number of vessels being painted in Liverpool at the time—40, to be exact—and also to the area requiring paint which is in the neighbourhood of three acres. The output of dazzled ships was definitely restricted to the supply of skilled painters obtainable, and the quantity of paint available. Warships were dealt with by their own crews.

The American destroyers and patrol vessels in European waters, for which I made upwards of 120 designs, were painted in the majority of cases by their own crews.

Soon after the commencement of unrestricted submarine warfare I saw a certain number of United States merchantmen painted to various ideas, on the lines of invisibility, and I must say it invariably seemed to me a waste of time and paint to paint them so. One I saw in Liverpool was closely covered with very small spots of grey, blue and pink of a more or less regular pattern. This, at half-a-mile and upwards showed as a flat tone of grey, and the long dark promenade decks and other shadow-casting projections would at once locate her to a watchful submarine, even supposing the hydrophone to be non-existent. These schemes were entirely abandoned after my visit to Washington in order to explain dazzle painting.

A certain number of our own warships were dazzle painted, these were mostly convoying cruisers, destroyers, minelayers and vessels working with merchant vessels. Two battleships were painted with a view to experiment with rangefinders; but I had stated in the early stages of the scheme that I attached no value to dazzle painting as an antidote to gunfire, as no paint has sufficient carrying power to be effective at the long ranges of a modern battle action.

The element of surprise is a big factor, and for this reason designs should be as varied as possible, and always different on both sides of the ship. A submarine sighting a vessel at some distance would probably make as extended observations as she dared, and in manœuvring to get a general view of the ship, would obtain an entirely different impression on crossing her bow. Those extended observations would increase the chances of her being seen by watchful look-outs. I believe there is little doubt that in many cases attacks on dazzle painted ships have been abandoned by the enemy, owing to the submarine finding too late that she had taken up a wrong position to ensure a successful shot.

A point of considerable interest on which I have unfortunately very little information is the German view of dazzle painting. Naturally, the enemy scoffed at our dazzle ships, and in one case a submarine commander professed to believe we were short of paint. Nevertheless, what came through in the way of evidence is somewhat convincing. The first report received was to the effect that German agents were sketching the designs of our vessels in Norwegian ports, and later that the German Admiralty had dazzle painted a liner and had attached her to the submarine training depot at Kiel. Finally, a number of the surrendered submarines were found to be painted in precisely the same manner as our merchant vessels, so that it looks as if considerable importance was attached to the training of their officers to the new conditions.

The French, Italian and United States Governments took up the scheme, and a certain number of Japanese ships were about to be painted at the time of the Armistice. I had four French naval officers under training in London, and the French Government started an establishment similar to our own. A large number of designs was made under my supervision. I visited Washington at the request of the United States Navy Department and explained dazzle painting which was then officially adopted.

There was great keenness on the part of captains of ships for their vessels to be painted. The idea became generally understood, and appreciated by them, for they saw numbers of these ships at sea, and found considerable difficulty in determining the course steered, and realized that if from a bridge, with a clear and unrestricted view, this was true, it must, in the nature of things, be more difficult from a periscope with limited vision and short observation.

All I have said up to the present has dealt exclusively with the uses of paint as an anti-submarine asset; but in addition to this, the above-water structure of a ship can be dealt with in such a way as to make it a matter of considerable difficulty to estimate course, and I will give you a few points which I have actually observed as being the most important.

These are mainly the masts, funnels, bridge and anchors. The old convention of raking the masts and stacks is of great assistance to a submarine when estimating the course of a ship. Where a ship of old design has two or more masts or funnels, this can be overcome to a certain extent by placing them in a vertical position. But by far the best camouflage is the single mast and funnel in close juxtaposition as in the Standard ship.

At the time when the enemy submarines were making a "dead set" at our oilers, and sinking them in large numbers, it was realized that something structural might be done to increase the difficulties of an accurate estimation of course. With this end in view it was decided to remove the masts and place the funnel in a vertical position. At the same time a short stump mast was erected about 8 ft. out of the centre line and close to the funnel. I have seen a number of these vessels after this treatment had been carried out, and when combined with dazzle painting it was frequently a matter of considerable difficulty to decide when the vessel was head on from a comparatively short distance.

The bridge, where, as in the majority of cases, this has a straight foreside, with rectangular ends, is a point much used by submarines for judging inclination. Dazzle painting in a great many cases breaks up a bridge in such a way that the actual angle of the bridge is impossible to determine; but there are conditions of light which no paint will overcome, and, consequently, some structural device would increase the difficulty of an attacking submarine. It has always seemed to me that the best and simplest device is a bridge built on a slight continuous curve with rounded corners, thus doing away with any sharp angles likely to throw definite shadows and so define the ends.

The bow anchors—where there are hawsepipe anchors—are a great assistance to determination of course. They should be dealt with so as to heave right up into slotted beds, with covering plates, or, failing this, set at different distances from the stem.

A flush decked steamer similar to the Admiralty pattern oilers of the "Leaf" class is far better than one with well decks.

The more erections you have on a ship's decks the greater chance a submarine has of getting your course. The wings at the various breaks of a steamer's decks, as in a three-island ship, are bad from an anti-submarine point of view.

I have embodied as far as possible in this paper the main features of interest as regards dazzle painting. There are, of course, a great many points on which it is only possible to touch lightly, but I hope from what I have told you, you will have gained a closer view of its objects.

As to its practical value in the war, the consensus of opinion is that a large number of vessels were saved by its use. A number of dazzled ships were, of course, hit by torpedoes, but a far larger percentage of these made port than ships painted light grey, owing to the submarine making an erratic shot, and so injuring the vessel in a less vital spot; that is, either right forward or aft. This demonstrates that even when in close contact with the target the commander was still uncertain as to the actual inclination.

Whether paint will ever play any part in future wars it is difficult to say; but judging by the adaptation of comparatively mediæval weapons to modern conditions on the Western Front, I think it would be safe to say that in what I hope will be the dim future, strange-looking craft will once more pursue their apparently erratic courses across the sea. K.S

TRADING AND THE RAISING OF THE BLOCKADE.—The Board of Trade have issued a leaflet, dated July, giving the conditions under which trading is permissible since the raising of the blockade. It deals with Germany, the territories previously included in the Austro-Hungarian Dominion, Turkey and Bulgaria, Scandinavia, Holland, Switzerland, Poland, Finland, Esthonia, Lettland and Lithuania. The Export Licence Department of the Board of Trade is at 1, Queen Anne's Gate Buildings, S.W. 1; and information as to import licences may be obtained from the Import Restrictions Department, 22, Carlisle-place, S.W. 1.

CATALOGUES.

Driving Chains.—We have received a copy of "The Link," the house magazine of the Coventry Chain Company, Limited—quite a satisfactory specimen of its kind.

Roller Bearings.—The Hyatt roller bearings as applied to plummer blocks, hangers, pillar brackets and countershafts, are illustrated in a small special catalogue issued by the makers, Messrs. Broom and Wade, Limited, High Wycombe.

Motor Tools.—A priced catalogue of small tools, small machines and general supplies issued by Messrs. Tuck and Blakemore, Limited, Coventry, is well illustrated, and in a form that will make it useful to those in charge of garage and other small workshops.

Drop Forgings.—Some notes on the manufacture of drop-forgings by Mr. Arthur Stubbs, Assistant Controller of Drop-Forgings in the Ministry of Munitions, have been republished in pamphlet form. Copies may be obtained from the Secretary of the Association of Drop-Forgers, 45, Newhall-street, Birmingham.

Electric Welding.—A dimensioned and priced list of electrodes for the arc process of cutting, welding and building up comes from the Alloy Welding Processes, Limited, Islington, and 149, Leadenhall-street, E.C. 3. There are special electrodes for mild, high tensile and manganese steels. The main part of the catalogue is filled with useful and practical information about the various processes, both resistance and arc.

Electric Contactor Panels.—Panels for starting non-reversing direct-current motors are shown in a special catalogue issued by the British Thomson-Houston Company, Limited, Rugby. These are for remote automatic control of shunt, series and compound motors of 110 volts to 550 volts and 10 h.p. to 300 h.p., in connection with the rise and fall of liquid in open or closed tanks, hydraulic accumulators, air compressors, &c.

Oil Engines.—A catalogue of two-cycle oil engines comes from Messrs. Penney and Porter, Limited, Lincoln, who have made similar engines since 1888. These engines will burn the cheapest and heaviest fuel and start from the cold state. They are made in 10 one-cylinder sizes, from 10 h.p. to 125 h.p., and up to 500 brake horse-power by combinations of two or four cylinders. The principal dimensions and capacities for 16 powers within these limits are given in tabular form. An illustration of the solid-injection engine made in 1888 fills an interesting page in the catalogue.

Small Pumps.—The very convenient hand pump known as the wing pump is well represented in a catalogue received from the Hamworthy Engineering Company, Limited, Poole, Dorset, and 76, Victoria-street, S.W. 1. The list includes 12 sizes of two-action and 13 sizes of four-action types for pipe connections from ¾ in. to 4 in. A two-action pump made in gun-metal with steel spindle, and less than half the weight of the cast-iron make, is shown for aircraft work. Rotary gear pumps for hand and power drive, a low-lift centrifugal pump and a hand diaphragm pump, are also shown. The last named is very useful for gritty or evil-smelling liquids.

Portable Machine Tool.—A drilling machine of considerable power adapted to be moved to heavy machines or structures under erection is shown in a catalogue from Messrs. Davie Brothers, Limited, Glasgow. Though described as a "radial" it differs essentially from that type. The machine with its motor is carried on a round column standing on a four-wheeled truck, and has 4 ft. 8 in. of vertical adjustment on the column, while both column and machine have 5 ft. of horizontal adjustment on slides on the truck. The drills work in horizontal position and have 18 in. of self-acting feed at 100 turns per inch and four changes of spindle speed. The weight is 2¼ tons.

Driving Chains.—A strictly manufacturing branch of engineering is represented by a catalogue from the Ewart Chain Belt Company, Limited, Derby. The links are castings of black heart malleable iron, a very strong and tough material. There is a large range of forms: simple links for forming a driving belt; and riveted, roller, and roller-bushed chains. The sizes are from ¾ in. pitch to 12 in. pitch. There are also many "attachments," brackets, spade pieces, &c., often cast integral with the links or rivets, for conveyor and elevator purposes. Sprocket wheels, idle pulleys, &c., are shown, and every item is made to standard size and full measurements and illustrations are given.

Large Forgings.—The difficulties of basing "specialisation" on scientific or even strictly technical lines is shown in dealing with very large forgings where the mere weight and size compels the forgemaster to become a master of monster machine tools also. Messrs. Walter Somers and Co., Limited, Halesowen, are amongst the largest forgemasters, and supply pieces up to 100 tons "machine finished or in the rough." A book of 50 photographic views of their works and plant includes forging presses up to 3,600 tons, steam hammers from 1 ton to 8 tons, and a series of lathes, boring, planing, slotting and other machine tools, chiefly on the mammoth scale. One piece of finished work is a steel screw 84 ft. 7 in. long, 11½ in. diameter and 2 in. pitch, forged from one ingot. Most of the work is in marine crankshafts, rudder frames, large guns, rolling mill parts, turbine rotors and gear wheels and rings, but smaller work is also represented. It is certainly essential that works of this kind should be fully employed in future so that their plant may be always in a state of vigorous development. The forgemaster suffered severely by unfair competition before the war. The large forge and the large machine tool will go or stay together.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACT OF 1907.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the Communicators are given in italics.

Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 6d.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Act.

GAS ENGINES, PRODUCERS, HOLDERS, &c.

126,200. J. L. Norton, Aston, Birmingham, and Norton Motors, Limited, Aston, Birmingham. Internal-Combustion Engines. (3 *Figs.*) June 22, 1918.—This invention refers to means for relieving compression in internal combustion engines of the type in which a lever *a* adjacent to one of the valve cam runners is mounted by such means as an eccentric which may form its fulcrum so that by rocking the mounting means the lever may be bodily moved into a position in which it is operative when struck by a suitable moving part. In this invention the eccentric is formed on a short rock shaft *d* mounted in the valve timing gear cover, and the rock shaft may be rocked by an arm or bell crank *f* providing a pedal surface, or surfaces, for operation by the foot if desired. Further, one arm of the lever is arranged beneath the rocker arm *b* or cam runner operating the tappet rod of the exhaust valve, and the other arm

Fig. 1.

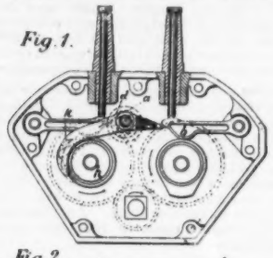
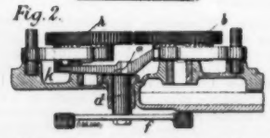
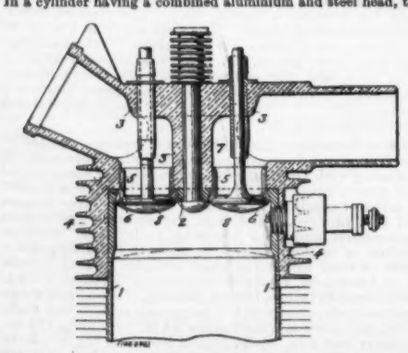


Fig. 2.



terminates adjacent to the inlet valve cam *h*, and upon this latter arm of the lever a projecting surface is formed for engagement by a projection dog or roller *k* formed on the cam or secured in a hole in the hump of the cam, for example, one of the holes for reducing the weight of metal in the cam. When the short rock shaft *d* is in normal position the lever fulcrum (the eccentric on the rock shaft) is in its bottom position, and the surfaces of the lever arms are clear of the dog on the cam aforesaid, and the runner or rocker for the exhaust valve respectively. For starting purposes the rock shaft is operated to raise the lever bodily or move it to one side, and the projection on its one arm then comes into the path of the dog of the cam, and is depressed, causing an upward stroke of the other arm which is transmitted through the rocker or runner to the exhaust valve tappet for the release of a part of compression through the exhaust valve in the known manner. (*Sealed.*)

126,370. The Daimler Company, Limited, Coventry, and A. E. Berriman, Coventry. Internal-Combustion Engines. (1 *Fig.*) January 18, 1917.—This invention refers to cylinders for internal-combustion engines of the kind which are of bi-metal construction, that is, in which two different metals are employed in the construction of the head. According to the invention, screwed open-ended ferrules are employed to serve as valve seats, and simultaneously also to serve the purpose of drawing and holding the two parts of the cylinder head together. In a cylinder having a combined aluminium and steel head, the



valve holes are bored out to a size sufficient to permit of the insertion of the steel ferrule, and these holes are screw-threaded preferably in the aluminium part only, and the ferrules are screw-threaded to suit. The ferrule is then screwed into the valve hole, and being formed with a shoulder is enabled thereby to draw the aluminium portion into close contact with the steel head of the cylinder. The barrel 3 of the cylinder is closed at one end by a partition 2 integral with the barrel and flat on its outer face, the barrel at that end being free from any integral external flange. The valve chamber casting 3, of aluminium, embodies the valve chambers and pipe attachments, is formed with a face which fits in surface contact upon the partition 2 of the cylinder, extends around the same externally as at 4, and is formed with fins. Valve holes are bored through the partition 2 and into the valve chamber casting 3 of a diameter sufficient to permit the insertion of steel ferrules 5, and each ferrule is externally screw-threaded to engage with screw threads formed in the boring of the valve chamber casting 3. The ferrules 5 are formed with shoulders 6, so that when screwed into position the ferrules draw and hold the valve chamber casting into close contact with the partition 2 of the cylinder. The partition 2 is recessed to receive the shoulders 6 of the ferrules 5, so that the shoulders 6 lie flush with the interior surface of the steel partition 2 forming the cylinder head proper. The ferrules are formed with valve seatings to receive valves 8. Screw threads with which the ferrules engage may be cut in the partition 2 as well as on the aluminium portion of the compound head. To lock the ferrules 5 *in situ* their edges may be overlapped with the head of a central bolt 7 passing through the partition 2 and through the valve chamber casting 3. (*Accepted May* 21, 1919.)

126,389. Sunbeam Motor Car Company, Limited, Wolverhampton, L. Coatalen, Wolverhampton, and H. C. M. Stevens, Wolverhampton. Internal-Combustion Engines. (2 *Figs.*) January 29, 1917.—This invention has for its object to provide a simple and light mechanism for operating valves carried in the head of the cylinders. A is one of a pair of brackets of aluminium connected by two studs B to a seating C on the cylinder D. The pair of brackets is placed one on each side of the cylinder head and support a camshaft E and valve-

Fig. 1.

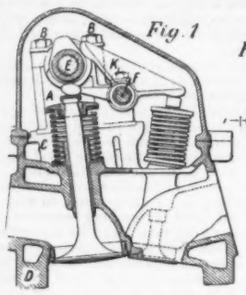
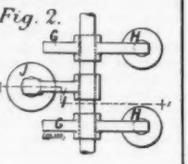


Fig. 2.



rocker spindle F. The valve-rocker spindle carries two rockers G to operate exhaust valves H, and one rocker I to operate the inlet valve J, the three rockers being rocked respectively by three cams on the camshaft. In order to hold the bracket securely to the cylinder, a third stud K passes through the extension of the bracket which carries the valve-rocker spindle, and it also passes through the spindle itself. The spindle and camshaft may be hollow and be coupled together so that oil may be supplied to the interior to lubricate the rockers and wherever desired. (*Accepted May* 21, 1919.)

126,583. A. H. Midgley, Acton, and C. A. Vandervell and Co., Limited, Acton. Internal-Combustion Engines. (2 *Figs.*) June 5, 1918.—The invention relates to means for advancing and retarding the ignition in ignition systems for internal-combustion engines, of the kind in which the ignition is effected by means of ignition coils having primary and secondary windings associated with a circuit-breaker and a distributor respectively. According to the invention, the cam of the circuit breaker and the distributor of one or more ignition sets of the kind referred to, are operated from a rotary member connected with the engine through the intermediary of a worm and worm wheel, one member of which is slidingly mounted on the shaft of the rotary member whilst the other member is mounted on the shaft carrying the cams of the circuit breakers and distributors associated with the ignition sets. Another feature of the

Fig. 1.

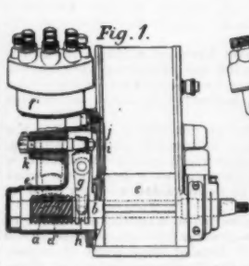
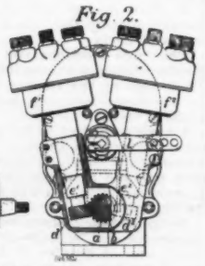


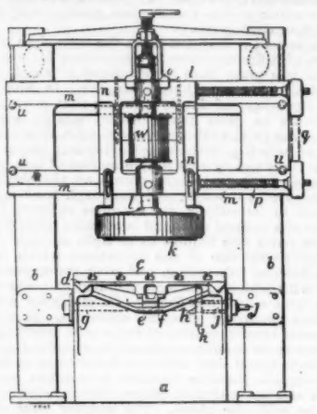
Fig. 2.



invention consists in mechanism for effecting the sliding movement of the one member of the gear by which the ignition is advanced or retarded. A worm *a* is slidingly mounted on the shaft *b* of the dynamo *c*, which is driven by the engine and generates the necessary current for the ignition, and is arranged in operative connection with two worm wheels *d*1, *d*2, mounted on the shafts *e*1, *e*2, which rotate the cams of the circuit-breakers and distributors belonging to two separate ignition sets and enclosed in the castings *f*1, *f*2, the latter being arranged in a plane perpendicular to the axis of the dynamo shaft. The means for sliding the worm comprise a pivoted fork *g* which engages with a collar *h* secured to or formed integral with the worm *a*, and is provided with teeth *i* engaging with a pinion *j* or other rotary or oscillatory toothed member mounted on a shaft *k* which is located between the distributor shafts *e*1, *e*2, above the part of the dynamo shaft carrying the worm *a*, and is provided with a hand-operated lever *l*. (*Accepted May* 21, 1919.)

MACHINE AND OTHER TOOLS, SHAFTING, &c.

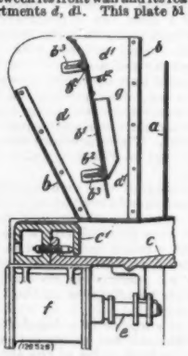
126,484. A. P. Smith, Coventry. Grinding Machines. (2 *Figs.*) May 15, 1918.—The invention has reference to grinding machines of the type comprising a travelling work table adapted to reciprocate between vertical standards carrying a vertically-adjustable cross slide upon which is mounted a laterally-adjustable tool holder, and has for its object to adapt the same for use in grinding the faces of moulding boxes and such like articles of comparatively large dimensions. *a* is the machine bed and *b* a pair of vertical standards, *c* is a work table travelling on guides *d*, and reciprocated by a pinion *e* engaging a rack *f* in the table; this pinion being mounted on a cross-shaft *g* driven by a power-multiplying gear *h* from a short hand or power shaft *j*. A grinder *k* is mounted on a vertical spindle *l* and is laterally adjustable upon a cross slide *m*. The cross slide *m* has upper and lower inclined slide surfaces, forming together a dovetailed slide on which a saddle *n* having two separated bearings *o* for the spindle *l* travels on a pair of traversing screws *p* rotated in synchronisation by any suitable means. The screws *p* are coupled by an endless chain *q* running on sprockets, so that as one screw is operated the other is similarly actuated. The cross slide *m* may be adjusted vertically to adapt the grinder to articles of different heights. For this purpose, a central vertical screw is provided passing through an internally screw-threaded lug on the back of the upper part of the slide, and to allow for the screw to be operated to adjust the slide, the latter is secured by clamping



bolts *u* at the sides of the vertical standards *b*. The upper end of the grinder spindle is received in an adjustable thrust bearing *v*; the middle portion of the spindle between the two separated bearings *o* of the saddle has a driving pulley *w* mounted upon it, and the lower end of the spindle receives the grinder *k*. An adjustable guard projecting down from the saddle surrounds the grinder. At the back of the vertical standards a cross-shaft for a driving pulley is mounted between a pair of jointed links or arms, one link of each pair being hinged at its upper end to the standards *b*, and the other being slotted so that the centre of the pulley shaft may be adjusted toward or away from the spindle to tension the belt to the pulley *w* as desired. (*Accepted May* 21, 1919.)

STEAM ENGINES, BOILERS, &c.

126,826. E. W. L. Nicol, London, and H. Schofield, London. Mechanical Stoking Apparatus. (2 *Figs.*) June 29, 1918.—The invention relates to mechanical stokers which operate with a reciprocating to-and-fro' motion. The main object of the invention is to facilitate the use of coke, anthracite, or non-bituminous fuel with these stokers in conjunction with bituminous coal, so that the necessity for intimately mixing the two different kinds of fuel is obviated. To this end, the feed hopper arrangement of the stoker is constructed to supply separately both bituminous and non-bituminous fuel, so that the stoker at each backward stroke, permits a compound charge, consisting of a portion of each kind of fuel, to drop from the hopper, the two portions forming a transverse row of fuel, and being at the next forward stroke thrust in towards the grate, which is thus covered with a succession of compound charges. *a* is the front of the boiler, having a reciprocating grate, *b* is the improved feed hopper and *c* the reciprocating feed plate on to which the fuel falls from the hopper. The feed plate has an adjustable feed block *c*1, and is operated by the piston rod *e* of a steam cylinder *f*. The feed hopper *b* is provided with a division plate *b*1 between its front wall and its rear wall, separating it into two compartments *d*, *d*1. This plate *b*1 is adjustable, so



that it can be placed nearer the back or front of the hopper, or altered in height by means of bolts and nuts projecting from guides *b*2. The compartment *d*1 adjacent to the furnace may be filled with coke, coke breeze or anthracite, whilst the other compartment *d* may be charged with bituminous or ordinary coal. By adjusting the plate *b*1 forward or backward, the relative outlet areas of the two compartments are varied, and hence the portions of the two fuels in the compound charges can be altered as required. The ram feed arrangements *c*, *f*, *e*, *e*1, is not altered, and operates as usual, but at each feed stroke it passes into the furnace a compound charge, and the fuel layer on the grate is made up of a succession of such charges packed against each other. By feeding the bituminous coal from the outer compartment the ram tends to thrust it under the anthracite, coke or breeze, and thus the grinding or abrading effect of the latter on the moving parts of the grate is reduced or obviated whilst the lubricating effect of the bituminous coal on the sliding surface is preserved. To enable the fireman to see that the inner hopper *d*1 is full, the adjacent partition is provided with a grating *d*3. Moreover, in order to facilitate the descent of the fuel one or more upright ribs *g* are provided on the inner face of the partition *b*1 which have been found to prevent the hanging up which is liable to occur, especially with coke. These ribs may be pieces of angle iron riveted to the partition. (*Accepted May* 21, 1919.)